CONTRIBUTIONS

TO

THE NATURAL HISTORY

OF THE

UNITED STATES OF AMERICA.

BY

LOUIS AGASSIZ.

FIRST MONOGRAPH.

IN THREE PARTS.—I. ESSAY ON CLASSIFICATION.—II. NORTH AMERICAN TESTUDINATA.—III. EMBRYOLOGY OF THE TURTLE; WITH THIRTY-FOUR PLATES.

VOL. I.

BOSTON:
LITTLE, BROWN AND COMPANY.
LONDON: TRÜBNER & CO.
1857.

CONTRIBUTIONS

TO

THE NATURAL HISTORY

OF THE

UNITED STATES OF AMERICA.

BY

LOUIS AGASSIZ.

FIRST MONOGRAPH.

IN THREE PARTS.—I. ESSAY ON CLASSIFICATION.—II. NORTH AMERICAN TESTUDINATA.—
III. EMBRYOLOGY OF THE TURTLE; WITH THIRTY-FOUR PLATES.

VOL. II.

BOSTON:
LITTLE, BROWN AND COMPANY.
LONDON: TRÜBNER & CO.
1857.

CAMBRIDGE:

ALLEN AND FARNHAM, PRINTERS.

NATURAL HISTORY

OF THE

UNITED STATES.

CONTRIBUTIONS

TO

THE NATURAL HISTORY

OF THE

UNITED STATES OF AMERICA.

BY

LOUIS AGASSIZ.

FIRST MONOGRAPH.

IN THREE PARTS.—I. ESSAY ON CLASSIFICATION.—II. NORTH AMERICAN TESTUDINATA.—III. EMBRYOLOGY OF THE TURTLE; WITH THIRTY-FOUR PLATES.

VOL. I.

BOSTON:
LITTLE, BROWN AND COMPANY.
LONDON: TRÜBNER & CO.
1857.

TO THE MEMORY

OF

IGNATIUS DÖLLINGER,

THE FOUNDER OF EMBRYOLOGY, WHO FIRST TAUGHT ME HOW TO TRACE THE DEVELOPMENT OF ANIMALS;

AND OF

FRANCIS CALLEY GRAY,

OF BOSTON, MY FRIEND AND ADVISER IN PLANNING THE PUBLICATION OF THIS WORK;

AND TO

JOSIAH QUINCY, JONATHAN PHILLIPS, NATHAN APPLETON,
DAVID SEARS, THOMAS GRAVES CARY,
WILLIAM STORY BULLARD, JOHN ELIOT THAYER,
JOHN AMORY LOWELL, AND STEPHEN SALISBURY,

WHO UNITED WITH HIM IN SECURING THE MEANS FOR ENGRAVING THE PLATES, AT A TIME WHEN IT APPEARED DOUBTFUL WHETHER THE SUBSCRIPTION WOULD COVER THE EXPENSE OF ITS PUBLICATION,

THIS WORK

IS INSCRIBED WITH DEEP GRATITUDE

BY

THE AUTHOR.

PREFACE.

Perhaps I cannot better express my deep sense of the generosity with which my labors in America have been supported, than by a simple narrative of the manner in which I have collected the materials for the series, of which this volume is the first, and of the growth and progress of the plan for its publication.

Since the time of my arrival in this country, now eleven years ago, I have lost no opportunity of making collections wherever my lecturing excursions led me; and, by my own efforts, and by the friendly aid of persons throughout the United States, who have shown from the beginning a warm interest in my scientific pursuits, I have succeeded in bringing together an extensive museum of purely American specimens. My opportunities for investigation were, of course, daily increased, and at the end of eight or nine years I had on hand a great quantity of materials, containing the results of my studies in this country; but the expense attending the collection and support of so large a museum more than exhausted the means which I was able to devote to it, and I felt obliged to renounce all idea of publishing the results of my labors. I had them in tangible form, not with any expectation of ever seeing them in print, but in the hope that after my death my collections and papers would be found a useful guide for others, and might be, in the end, of some service to science in America.

It is now two years since, in conversation with Mr. Francis C. Gray, of Boston,—now no longer living to see the result of his disinterested and generous efforts in behalf of science,—I mentioned to him the numerous preparations which I had made to illustrate the Natural History of North America, and my regret that the costliness of such works must prevent the publication of the materials I had collected. He entered at once into the matter with an energy and hopefulness which were most inspiring: spent some time in examining my manuscripts; and, having satisfied himself of the feasibility of their publication, set on foot a subscription, of which he took the whole direction himself, awakening attention to it by personal application to his friends and acquaintances, by his own liberal subscription, by letters, by articles in the journals, and by every means which the warmest friendship and the most genuine interest in science could suggest. He was rewarded beyond his utmost hope or mine, by the generous response of the public to whom he appealed. We had fixed upon five hundred subscribers as the number necessary, to enter upon the publication with safety; and we had hoped that the list might perhaps be increased to seven or eight hundred. At this moment it stands at twenty-five hundred: a support such as was never before offered to any scientific man for purely scientific ends, without any reference to government objects or direct practical aims, — although I believe no scientific investigations, however abstruse, are without practical results. My generous friend did not live to witness the completion of the first volume of the series, which without his assistance could not have appeared, but he followed with the deepest interest every step in its progress, to the day of his death; — he did live, however, to hear the echo which answered his appeal to the nation, in whose love of culture and liberality towards all intellectual objects he had felt so much confidence. From all the principal cities, and from towns and villages in the West, which a few years since did not exist; from California, from every corner of the United States, — came not only names, but proffers of assistance in the way of collections, and information respecting the distribution and habits of animals, which have been of the utmost assistance in the progress of the work.

It has been my wish to make my part of the undertaking worthy of the interest so liberally shown by the community; and in this I have been greatly assisted by the liberal views which the publishers have taken, from the beginning, with regard to its publication. And now, in presenting this volume to the American public, I would take occasion to repeat, — what has already been stated in a circular to my subscribers, — that the plan of the work has been enlarged, in consequence of the liberality of the subscriptions, in a manner which has delayed the publication for nearly a year, but which has, I believe, made the book more valuable. I have thus been able to double, at the least, the number of figures upon most of the plates, and to include in the text, generalizations which are the results of my whole scientific life; so that this volume, — which, according to the original plan, was designed to be one of special descriptive Zoölogy, — contains, in addition to a description of the North American Turtles, a review of the classification of the whole animal kingdom. I have also endeavored to make it a text-book of reference for the student, in which he may find notices of all that has been accomplished in the various departments of Natural History alluded to, and which, I trust, young American naturalists will take not only as an indication of what has been done, but as an earnest of what remains to be done, in the fields now open to our investigation.

In consequence of these additions, the first volume is more bulky than was intended, but contains no plates; while the second, in order to avoid mixing heterogeneous subjects, had to be brought to a close before its size amounted to what it should be; but in the succeeding volumes full compensation will be made for this, and measures taken to bring them forward with more promptitude.

With reference to the future progress of Zoölogy in this country, it is particularly desirable that investigators should not allow themselves to be carried away by the almost inexhaustible diversity of species, so as to confine their efforts to describing merely what is new, for however desirable it may be that all our species should be correctly named, described, and delineated, such labors are, in fact, only the preliminary steps towards deeper and more philosophical studies; and the sooner attention is turned to the mode of life of all our animals, to their geographical distribution, their natural affinities, their internal structure, their embryonic growth, and to the study of fossil remains, the sooner will the investigations of American naturalists contribute largely to the real advancement of science, and the investigators themselves acquire an independent standing among scientific men. I am well aware, while writing this, that there are already many who pursue the study in that truly scientific spirit which has brought Natural History to its present prosperous state; my remarks, therefore, do not apply to these noble devotees of truth. But I know equally well, that there are too many who fancy that describing a new species, and hurrying to the press a hasty and mostly insufficient diagnosis, is a real scientific achievement. These I would warn from the deceptive path, adding, that a long experience has taught me that nothing was ever lost to an investigator by covering, as far as possible, the whole ground of any subject of inquiry; and that, though at times a subject may seem to have lost some of its value for being less novel, it generally gains tenfold in scientific importance by being presented in the fullest light of all its natural relations. It is chiefly this conviction which has induced me to keep to myself for so many years the results of my investigations in this country; and if, in the course of this publication, I am occasionally compelled to offer fragmentary information upon many parts of my subject, it is simply because the time has come with me when I must publish what I have been able to observe, if I would publish at all.

Scandinavia, Germany, and France afford us striking examples of the new impulse science has received, in consequence of the gradual exhaustion of the field afforded them for descriptive Zoölogy. As soon as most of the species of these countries had been described, after Linnæus had begun to register systematically the whole animal kingdom, those who were denied the opportunity of visiting foreign countries, or of receiving large supplies of new species from distant lands, applied themselves to the investigation of the internal structure of the animals already described, and to the study of their habits, their metamorphoses, their embryonic growth, etc. Never did Zoölogy receive a more important impulse than at the time when German students began to trace with untiring zeal the earliest development of all the classes of the animal kingdom, and some Scandinavian observers pointed out the wonderful phenomena of alternate generations; and, if we would not remain behind in the generous race now running in science, we must take good care, while we investigate our Fauna and describe our new species, to combine the investigation with all those considerations which give true dignity to science, and raise it above the play of the mere collector.

I must beg my European readers to remember, that this work is written in America, and more especially for America; and that the community to which it is particularly addressed has very different wants from those of the reading public in Europe. There is not a class of learned men here, distinct from the other cultivated members of the community. On the contrary, so general is the desire for knowledge, that I expect to see my book read by operatives, by fishermen, by farmers, quite as extensively as by the students in our colleges, or by the learned professions; and it is but proper that I should endeavor to make myself understood by all.

Lieber, — whose testimony cannot be questioned, as, like myself, he did not first see the light of day in America, — justly remarks, what is particularly true of the United States, "that one of the characteristic features of the nineteenth century in the great history of the western Caucasian race, is a yearning for knowledge and culture far more general than has ever existed at any previous period on the one hand, and on the other a readiness and corresponding desire in the votaries of knowledge to diffuse it, — to make the many millions share in its treasures and benefits."[1]

It must not be overlooked also, that, while our scientific libraries are still very defective, there is a class of elementary works upon Natural History widely circulated in Europe, and accompanied with numerous illustrations, which are still entirely unknown in this country. In most of our public libraries there are no copies of such works as Swammerdam, Roesel, Reaumur, Lyonet, etc., nor any thing, within the reach of the young, like those innumerable popular publications, such as Sturm's Fauna, the Insect Almanachs, Bertuch's Bilderbuch, and the neatly illustrated school-books published in Esslingen, or like the series of valuable treatises illustrating the Natural History of England, and the popular sea-side books, which, in the Old World, are to be found in the hands of every child. The only good book upon Insects in general, yet printed in America, is "Harris's Treatise on the Insects injurious to Vegetation in Massachusetts"; and that book does not contain even a single wood-cut. There has not yet been published a single text-book embracing the whole animal kingdom. This may explain the necessity I have felt of introducing frequently in my illustrations, details which, to a professional naturalist, might seem entirely out of place.

I have a few words more to say respecting the first two volumes, now ready for publication. Considering the uncertainty of human life, I have wished to bring out at once

[1] Columbia Athenæum Lecture, by Francis Lieber, Columbia, S. C., 1856, p. 7.

a work that would exemplify the nature of the investigations I have been tracing during the last ten years, and show what is likely to be the character of the whole series. I have aimed, therefore, in preparing these two volumes, to combine them in such a manner as that they should form a whole. The First Part contains an exposition of the general views I have arrived at, thus far, in my studies of Natural History. The Second Part shows how I have attempted to apply these results to the special study of Zoölogy, taking the order of Testudinata as an example. I believe, that, in America, where Turtles are everywhere common and greatly diversified, a student could not make a better beginning than by a careful perusal of this part of my work, specimens in hand, with constant reference to the second chapter of the First Part. The Third Part exemplifies the bearing of Embryology upon these general questions, while it contains the fullest illustration of the embryonic growth of the Testudinata.

As stated above, I have received contributions from every part of the country, and upon the most diversified subjects, relating to my studies, which I shall mention in their proper place in the course of the publication of my work, and give to all due credit for their assistance. For the present, I must limit myself to returning my special thanks to those who have materially contributed to the preparation of the first two volumes, now about to be published together.

Above all, I must mention the Smithsonian Institution, whose officers, in the true spirit of its founder, have largely contributed to the advancement of my researches, by forwarding to me for examination, not only all the specimens of Testudinata collected for the museum of the Institution, but also those brought to Washington by the naturalists of the different parties that have explored the western territories, or crossed the continent with the view of determining the best route for the Pacific Railroad. These specimens have enabled me to determine the geographical distribution of this order of Reptiles with a degree of precision which I could not have attained without this assistance. Besides this, Professor J. Henry, the liberal Secretary of the Institution, has caused special collections of Turtles to be made for me in those parts of the country from which I had few or no specimens, and Professor Baird has spared no pains to carry out these benevolent intentions. I have also received from Professor Baird a number of interesting specimens, which he himself collected during his extensive excursions. To these gentlemen, therefore, I am indebted in the highest degree. Other public institutions have also afforded me valuable assistance. In Philadelphia, I have been able to compare the specimens of the museum of the Academy of Natural Sciences, which contains the originals of the great work of Dr. Holbrook on the Reptiles of North America. The Trustees of the University of Oxford, in Mississippi, have intrusted to me, at the request of Dr. L. Harper, the Reptiles of the State Survey for examination; and besides these, I have received many valuable specimens from that State, through Prof. B. L. Wailes. Prof. Alexander Winchell has also sent me all those of the museum of the University of Ann Arbor, in Michigan; and, through the kindness of Professor Poey of the University of Havana, I have been able to compare the Turtles of the island of Cuba with those of the continent of North America. Prof. Jeffries Wyman has allowed me, with the same liberality, the free use of the preparations relating to Turtles contained in the museum of Comparative Anatomy of our University. I have also received valuable specimens for comparison from the museum of the Essex Institute, in Salem.

Among private individuals who have largely contributed to my collection of Turtles, I have to mention, first, Mr. Winthrop Sargent, of Natchez. Not satisfied with collecting extensively the Turtles in the neighborhood of his residence, he undertook a journey of many hundred miles for the special purpose of securing all the species living in the adjoining regions, and, having completed the survey, set out with a cargo of living Turtles, and brought them safely alive to me in Cambridge, after a journey of over a thousand miles. Such devotion to the interests of science, on the part of a gentleman who is not himself a naturalist, deserves more than a passing notice. To him I am indebted for the opportunity of studying several species, alive, which have probably never been seen before, by any naturalist, in a fresh state.

It would be difficult for me to convey an adequate idea of the value of all the different contributions I have received for this part of my work. In some instances they consisted perhaps of a few specimens of well-known species, but then they came from regions where their presence had not been ascertained before; or the specimens were so numerous as to afford ample opportunity to determine the range of their variations; or there were among them, young ones, in a state of development not before observed. Yet I may well say, that, however numerous have been the invoices of Turtles which I received from the different States, not one was superfluous; and I have frequently regretted that I could not obtain more, for there are still several species, the eggs or the young of which I have not been able to get.

The better to show to what extent these specimens were sufficient satisfactorily to determine the geographical distribution of our Turtles, I will enumerate them in geographical order. From the British Provinces, my information was chiefly derived from collections and notices sent me by Mr. M. H. Perley, of St. John, and Mr. Wm. Couper, of Toronto. In New England, I have myself collected largely; but I have also received valuable contributions from the late Rev. Zadock Thompson, of Burlington; from Mr. James E. Mills, of Bangor; from the late Dr. W. I. Burnett, of Boston; from Capt. N. Atwood, of Provincetown; from Mr. D. Henry Thoreau, of Concord; from Mr. F. W. Putnam, of Salem; from Mr. Sidney Brooks, of Harwich; from Mr. Sanborn Tenney, of Auburndale; and from Mr. J. W. P. Jenks, of Middleboro'. Messrs. Tenney and Jenks have repeatedly sent me the Turtles of our neighborhood by hundreds. From the State of New York, I have received specimens from Colonel E. Jewett, of Utica; from Mr. Albert G. Carll, of Jericho, Long Island; and from an anonymous contributor in the vicinity of Rome. Mr. A. Mayor has sent me those of New Jersey, with interesting remarks upon the height at which they are found in the Cooley Mountains. From Pennsylvania, I have received very extensive collections and highly valuable information. Among the votaries of Herpetology, I must mention, first, Major LeConte, to whom science is indebted for the first accurate account of the North American Testudinata in general. Next to him I am most indebted to Prof. S. S. Haldeman, and to Dr. E. Hallowell, for series of all the species of the State. Dr. John LeConte, Dr. Wm. Darlington, and Dr. E. Michener have also sent me valuable specimens and notices; and to Dr. J. Leidy I owe the communication of the fossil remains of this order of Reptiles preserved in the splendid museum of the Academy of Natural Sciences. To Prof. Baird I am also greatly indebted for specimens from Pennsylvania and Western New York; but especially for a large collection of fossil bones of Turtles from the caves near Carlisle.

From Ohio, I have received specimens and notices from Dr. J. P. Kirtland, of East Rockport; from Prof. E. B. Andrews, of Marietta; from Messrs. Jos. Clark and David H. Shaffer, of Cincinnati; and from Mr. George Clark, of Toledo. From Indiana, from Prof. Richard Owen, of New Harmony; and Mr. F. C. Hill, of Delphi. From Illinois, from Dr. Watson, of Quincy; and from Messrs. R. P. Stevens, T. H. McChesney, and Robert Kennicott. Mr. Kennicott has furnished me with interesting data respecting the geographical distribution of the soft-shell Turtles in the tributaries of the Mississippi. From Michigan and Wisconsin, I have received very fine series of specimens, which have enabled me to ascertain the specific differences that distinguish the western Chrysemys from that of the Eastern States, and also numerous specimens of Emys Meleagris. I am particularly indebted for these to Dr. P. R. Hoy, of Racine; to Mr. J. A. Lapham, of Milwaukee; to Dr. Manly Miles, of Flint; and to Prof. A. Winchell, Dr. A. Sager, and Mr. D. M. Johnson, of Ann-Arbor. Dr. John H. Rauch, of Burlington, Iowa, has sent me large numbers of specimens from that State. From Missouri and Arkansas, I have received a great many specimens through the kindness of Dr. George Engelmann, of St. Louis; and of Mr. George Stolley, now in Texas, who collected very extensively for me in the western and south-western parts of Missouri, and later, in Arkansas and Texas. From the Territory of Minesota, Mr. James M. Barnard, of Boston, has secured for me a dozen fine specimens of an extremely rare species of Chrysemys, heretofore known from a single specimen preserved in the museum of the Academy of Philadelphia, and supposed to have been found in Oregon. My acquaintance with the Testudinata of the other western territories, and with those of Delaware, Maryland, and Virginia, is chiefly derived from the contributions of the Smithsonian Institution, among which were the valuable collections of Dr. R. O. Abbott, and of Dr. C. B. Kennerley. From Kentucky and Tennessee, I have received specimens from Messrs. N. A. Gwyn, H. C. Taylor, Prof. I. D. Lindsley, and interesting notices from Dr. Samuel Cunningham. From North Carolina, from Dr. J. H. Gibbon, Mr. S. T. Thayer, Dr. C. L. Hunter, Mr. W. C. Kerr, and Professor Baird. Mr. Henry Harrisse has lately sent me the drawing of a very remarkable young specimen of Ptychemys concinna with two distinct heads.

Dr. Edward Holbrook, by his extensive works upon the subject, has rendered South Carolina classic ground for Herpetology; and to him I am indebted for the largest supplies of the species found in that State. I have also received a variety of specimens from Dr. W. R. Gibbs, of Columbia, and from Mr. Barnwell, of Beaufort. From Georgia, I have received invaluable contributions. Dr. W. C. Daniell and Col. A. S. Jones have caused specimens to be collected for me all over the State, while Prof. LeConte, of Athens; Dr. Wm. Gesner, of Columbus: Prof. N. A. Pratt, Jr., and Mr. B. I. King, of Roswell: Mr. Alex. Gerhardt, of Whitfield County; and Mr. R. H. Gardiner, have sent me large numbers of specimens from their respective districts. The species of Alabama have also been furnished to me in large numbers by Dr. J. C. Nott, Col. Deas, and Mr. Albert Stein, of Mobile; by Mr. Thos. M. Peters, of Moulton; and by Mr. Th. P. Hatch, of Florence. From Florida, I have received interesting specimens from Dr. L. M. Jeffries, of Pensacola; from Mr. F. Eppes, of Tallahassee; from Mr. Theodore Lyman, of Boston; and from Mr. F. W. Putnam, of Salem. Numerous as these invoices were, I have received yet more extensive collections from Mississippi and Louisiana, through the kindness of the Rev. Dr. Tho. S. Savage, of Pass Christian; Mr. W. Sargent, Prof. B. S. C. Wailes, and Benjamin Chase, of Natchez; Dr. L. Harper, of Oxford; and Prof. R. H. Chilton, Dr. N. B. Benedict, Dr. B. Dowler, and Mr. T. C. Copes, of New Orleans.

From Texas, and the adjoining parts of Mexico, I have examined the rich collections made under the direction of Col. Emory during the boundary survey, and those secured by the Smithsonian Institution from the late Mr. Berlandier. To the Rev. Edward Fontaine, of Austin, I am indebted for valuable information respecting the habits of the large Snapping Turtle of the South-western States; and to Dr. C. B. Kennerley and Mr. George Stolley, of Williamson County, for numerous specimens. Mr. C. J. Hering, of Surinam, has provided me with ample means to compare the species of the northern parts of South America with those of the United States and of Mexico. From California and the Galapagos Islands I have also received extensive collections, especially from California, through the kindness of Messrs. Thomas G. Cary, Jr. and A. F. Branda, of San Francisco, who have sent me beautiful series of specimens of the only fresh-water Turtle found on the western slope of the continent of North America, and also specimens of the Sea Turtles of the Pacific coast. I am indebted to Mr. Charles Pickering for notices respecting the Turtles of Oregon; and to Mr. Patrick H. Frey, of New York, for a living specimen of the large Galapago Turtle.

The notices respecting the mode of life and the distribution of our Turtles which were sent to me by the Rev. Thomas S. Savage of Pass Christian, the Rev. Edw. Fontaine of Austin, Mr. W. Sargent of Natchez, and Mr. Jenks of Middleboro', are among the most valuable of the kind I have received; and to Mr. Jenks I am indebted for most of the eggs the development of which I have been able to trace. For a number of years he has provided me annually with many hundreds of eggs, of all our common species. I have also received many valuable invoices of eggs from Mr. T. W. P. Lewis, of Key West; from the Hon. J. Townsend, of Edisto, in South Carolina; from Dr. John Rauch, of Burlington, Iowa; from Franklin C. Hill, of Logansport, Indiana; from Dr. Michener, of Arondale, in Pennsylvania; from Mr. Winthrop Sargent, of Natchez; from Mr. Eppes, of Tallahassee; from Dr. Nott, of Mobile; from Prof. Baird, of the Smithsonian Institution; from the late Rev. Z. Thompson, of Burlington, Vermont; from Dr. A. Sager, of Ann-Arbor; from Major and Dr. LeConte, of Philadelphia; from Dr. Hoy, of Racine; from the late Dr. Burnett, of Boston; from Mr. Sanborn Tenney, of Auburndale; and from a number of intelligent boys of the vicinity of Cambridge. I have myself obtained many rare eggs from species kept alive in my garden, and raised a large number of young Turtles.

It may not be superfluous to state, that most of these specimens were sent alive to Cambridge, so that I had the amplest opportunity of studying their natural attitudes, their modes of moving and of eating, and sometimes the manner in which they lay their eggs. I have of course availed myself of these favorable circumstances to examine and compare the largest possible numbers of specimens of the same species, in order to determine the range of variations of each of them. There are many species, of which I have examined many hundreds of specimens. I have also caused innumerable drawings of these specimens to be made by my tried friend, J. Burkhardt, representing their varieties of color and form, and their different attitudes. These drawings and sketches would fill over one hundred plates, and are too numerous to be published in this series; but I shall avail myself of every opportunity to publish them, in the style of Plates 26 and 27. Minor contributions are mentioned, in their proper places, in the text.

There is another kind of assistance, which I take great satisfaction in recording, as it comes from young friends and former pupils. Among them there is one, a lineal descendant of one of the great patriots of the American Revolution, whose modesty forbids that I should mention him by name. On hearing of my intention to publish a work on the Natural History of the United States, he immediately came forward with a most liberal pecuniary contribution to my undertaking. From other pupils I have derived assistance in the prosecution of the work itself. Mr. James E. Mills, of Bangor, (Maine,) has worked out for me the special characters of the families of the Testudinata; and Dr. Weinland has helped me in revising the anatomical characters of the order, in accordance with the principles laid down in the First Part of the work; while Mr. H. James Clark has assisted me from the beginning of my investigation of the embryology of these animals, and drawn, with untiring patience and unsurpassed accuracy, most of the microscopic illustrations which adorn my work. I owe it to Mr. Clark to say, that he has identified himself so thoroughly with my studies since he took his degree in the Lawrence Scientific School, that it would be difficult for me to say when I ceased to guide him in his work. But this I know very well, — that he is now a most trustworthy observer, fully capable of tracing for himself the minutest microscopic investigation, and the accuracy of his illustrations challenges comparison. I esteem myself happy to have been able to secure the continued assistance of my old friend, Mr. A. Sonrel, in drawing the zoölogical figures of my work. More than twenty years ago, he began to make illustrations for my European works; and ever since he has been engaged, with short interruptions, in executing drawings for me. The mastery he has attained in this department, and the elegance and accuracy of his lithographic representations, are unsurpassed, if they are anywhere equalled. For all these invaluable services, it is but justice that I should make this public acknowledgment.

As questions of omission or oversight may come up hereafter respecting the different topics discussed in these volumes, it is proper for me to state, that the printing of the text of the first volume has been completed more than ten months; indeed, the First Part passed through the press fifteen months ago. My object in delaying its publication was chiefly to await the time when I could lay before my readers a fair specimen of the plates, no one of which relates exclusively to the first volume. The text of the second volume was finished in June last. But here I met with another difficulty. The subject of this volume did not require a sufficiently large number of plates to be fully equivalent to that required for two volumes, when counting the plates as they now are, as simple plates, notwithstanding the large increase of figures crowded upon each, and it seemed inappropriate to bind together plates belonging to different volumes. I shall therefore have to make up for this deficiency by a sufficient addition of plates to the third volume, the subject of which naturally requires very numerous illustrations. I hope no disappointment will be felt, on this account, by my subscribers, for in the course pursued by the publishers and by myself, they will readily see that we have aimed to do every thing in our power to respond to the liberality of the subscription; and I trust the following volumes will afford additional evidence of this disposition.

LOUIS AGASSIZ.

CAMBRIDGE, October 3, 1857.

LIST OF SUBSCRIBERS

TO THIS WORK IN THE UNITED STATES.

MAINE.

Willard Small,	Auburn.
Bangor Mechanics' Association,	Bangor.
Bangor Mercantile Association,	"
Zina Hyde,	Bath.
James T. Patten,	"
Wm. E. Payne,	"
J. H. Rogers,	"
R. M. Chapman,	Biddeford.
Bowdoin College,	Brunswick.
R. H. Gardiner,	Gardiner.
George Merrick,	Hallowell.
J. A. Swan,	Kennebunk.
John C. Caldwell,	East Machias.
C. S. Daveis,	Portland.
Thomas A. Deblois,	"
Henry S. Edwards,	"
James L. Farmer,	"
Oliver Gerrish,	"
Abner Lowell,	"
J. M. Wood,	"
William Wood,	"
Waterville College,	Waterville.
Edwin Noyes,	"

NEW HAMPSHIRE.

John E. Tyler,	Concord.
James J. Thorndike,	South Deerfield.
Moses L. Morse,	Dover.
Chas. A. Tufts,	"
H. Y. Hayes,	Great Falls.
Thomas E. Hatch,	Keene.
George B. Twitchell,	"
Manchester City Library,	Manchester.
J. G. Cilley,	"
Daniel Clark,	"
Charles H. Dalton,	"
E. Anderson,	Milford.
Miss E. A. Livermore,	"
J. Warren Towle,	Portsmouth.

VERMONT.

J. S. Spalding,	Barre.
Samuel White Thayer, Jr.,	Burlington.
D. W. Boutwell,	Factory Point.
Edward T. Fairbanks,	St. Johnsbury.
Erastus Fairbanks.	St. Johnsbury.
Franklin Fairbanks,	"
Horace Fairbanks,	"
Wm. Henry Thayer,	Woodstock.

MASSACHUSETTS.

Amherst College Library,	Amherst.
Leander Wetherell,	"
Andover Theological Seminary,	Andover.
Edward Nye Bates,	Barre.
E. S. Wheeler,	Berlin.
Wm. Endicott, Jr.,	Beverly.
Benj. O. Peirce,	"
Massachusetts State Library, 3 copies,	Boston.
The Public Library, 3 copies,	"
American Acad. of Arts and Sciences,	"
Boston Athenæum,	"
Boston Library Society,	"
Boston Society of Natural History,	"
Mercantile Library,	"
Mass. Charitable Mechanics' Assoc.,	"
Henry W. Abbot,	"
C. Francis Adams,	"
C. Frederick Adams,	"
F. Alger,	"
Mrs. H. Allen,	"
Charles Amory,	"
William Amory,	"
Wm. T. Andrews,	"
Nathan Appleton,	"
Samuel A. Appleton,	"
T. G. Appleton,	"
Wm. Appleton,	"
O. D. Ashley,	"
Edward Austin,	"
S. Austin,	"
Eben Bacon,	"
Francis Bacon,	"
Wm. B. Bacon,	"
Richard Baker, Jr.,	"
J. W. Balch,	"
Wm. A. Bangs,	"
G. M. Barnard,	"
Jas. M. Barnard,	"
S. B. Barrell,	"
Sidney Bartlett,	"
Francis Bassett,	"
B. E. Bates,	"
George Bates,	"
Ives Gilman Bates,	"
John D. Bates,	"
Alexander Beal,	"
J. M. Beebe,	Boston.
A. E. Belknap,	"
Mrs. John Belknap,	"
S. A. Bemis,	"
George Bethune,	"
Jacob Bigelow,	"
Amos Binney,	"
S. Parkman Blake,	"
J. A. Blanchard,	"
Henry T. Blodget,	"
Wm. H. Boardman,	"
William Boott,	"
J. N. Borland,	"
Thos. T. Bouvé,	"
Henry I. Bowditch,	"
J. Ingersoll Bowditch,	"
N. I. Bowditch,	"
F. H. Bradlee,	"
J. Bowdoin Bradlee,	"
Josiah Bradlee,	"
Samuel Bradstreet,	"
Gardner Brewer,	"
E. D. Brigham,	"
M. Brimmer,	"
Gorham Brooks,	"
P. C. Brooks,	"
J. W. Brown,	"
Vernon Brown,	"
Charles Browne,	"
S. H. Bullard,	"
Wm. S. Bullard,	"
B. F. Burgess,	"
Alvah A. Burrage,	"
Jas. P. Bush,	"
F. T. Bush,	"
P. Butler, Jr.,	"
Henry Cabot,	"
George D. Carter,	"
George B. Cary,	"
Thomas G. Cary,	"
C. C. Chadwick,	"
Edward Chamberlain,	"
J. G. Chandler,	"
Walter Channing,	"
Theodore Chase,	"
C. F. Chickering,	"

T. E. Chickering,	Boston.
George H. Child,	"
Rufus Choate,	"
Joseph W. Clark,	"
Charles R. Codman,	"
Edward Codman,	"
W. E. Coffin,	"
Gardner Colby,	"
James C. Converse,	"
Joseph Coolidge,	"
Joseph S. Coolidge,	"
T. Jefferson Coolidge,	"
W. H. C. Copeland,	"
Joseph Cotton,	"
Alpheus Crosby,	"
Edward A. Crowninshield,	"
F. B. Crowninshield,	"
Frederic Cunningham,	"
J. A. Cunningham,	"
C. P. Curtis,	"
Francis Curtis,	"
George T. Curtis,	"
T. B. Curtis,	"
Martin G. Cushing,	"
Charles S. Cutter,	"
P. R. Dalton,	"
F. Darracott,	"
Adolphus Davis,	"
James Davis, Jr.,	"
William Dehon,	"
Franklin Dexter,	"
T. C. A. Dexter,	"
J. Dix,	"
A. Douglas, Jr.,	"
E. G. Dudley,	"
James A. Dupee,	"
Edmund Dwight,	"
J. Wiley Edmands,	"
Samuel A. Eliot,	"
Jonathan Ellis,	"
John L. Emmons,	"
N. H. Emmons,	"
Edward Everett,	"
George N. Faxon,	"
R. S. Fay,	"
Albert Fearing,	"
A. H. Fiske,	"
Richard Fletcher,	"
John S. H. Fogg,	"
J. M. Forbes,	"
R. B. Forbes,	Boston.
William Foster,	"
William H. Foster,	"
N. Francis,	"
William F. Freeman,	"
N. L. Frothingham,	"
William H. Gardiner,	"
George Gardner,	"
H. J. Gardner,	"
John L. Gardner,	"
Joseph P. Gardner,	"
Benjamin F. Gibbs	"
Joseph B. Glover,	"
T. A. Goddard,	"
Ozias Goodwin,	"
B. A. Gould,	"
F. A. Gray,	"
F. C. Gray,	"
John C. Gray,	"
William Gray,	"
Benjamin D. Greene,	"
W. W. Greenough,	"
Mrs. Henry Grew,	"
Thomas Groom,	"
Benjamin Guild,	"
Edward Habich,	"
Andrew T. Hall,	"
Edwin H. Hall,	"
H. S. Hallet,	"
G. G. Hammond,	"
Samuel Hammond,	"
Alpheus Hardy,	"
Nathaniel Harris,	"
W. A. Harris,	"
Peter Harvey,	"
Daniel Harwood,	"
Franklin Haven,	"
George Hayward,	"
John T. Heard,	"
A. Hemenway,	"
N. H. Henchman,	"
C. H. Herman,	"
William Heywood,	"
George Higginson,	"
J. A. Higginson,	"
Richard Hildreth,	"
William Hilton,	"
A. Hollingsworth,	"
O. W. Holmes,	"
N. Hooper,	"

R. C. Hooper,	Boston.
R. W. Hooper,	"
S. Hooper,	"
George Howe,	"
Jabez C. Howe,	"
S. G. Howe,	"
Osborn Howes,	"
H. H. Hunnewell,	"
John L. Hunnewell,	"
J. Iasigi,	"
Henderson Inches,	"
Charles Jackson,	"
P. T. Jackson,	"
John Jeffries,	"
John Jeffries, Jr.,	"
T. A. Johnston,	"
George B. Jones,	"
Charles G. Kendall,	"
Catherine E. U. Kimball,	"
Moses Kimball,	"
Franklin King,	"
George H. Kuhn,	"
Thomas Lamb,	"
Abbott Lawrence,	"
Abbott Lawrence, Jr.,	"
Amos A. Lawrence,	"
James Lawrence,	"
Samuel Lawrence,	"
William R. Lawrence,	"
Henry Lee, Jr.,	"
Miss R. Lee,	"
Thomas Lee,	"
W. Raymond Lee,	"
Charles P. Lewis,	"
William R. Lewis,	"
Winslow Lewis,	"
Ezra Lincoln,	"
J. C. Lindsley,	"
James Lodge,	"
John E. Lodge,	"
Ammi C. Lombard,	"
Israel Lombard,	"
B. T. Loring,	"
Charles G. Loring,	"
F. C. Loring,	"
J. S. Lovering,	"
Augustus Lowell,	"
Francis C. Lowell,	"
John A. Lowell,	"
Arthur T. Lyman,	"
S. P. Lyman,	Boston.
Charles Manning,	"
J. B. Mansfield,	"
W. T. R. Marvin,	"
William P. Mason,	"
D. R. McKay,	"
Levi B. Meriam,	"
Charles H. Mills,	"
James K. Mills,	"
Thomas Minns,	"
George R. Minot,	"
William Mitchell,	"
C. J. Morrill,	"
Frederick P. Moseley,	"
F. F. Müller,	"
H. Newman,	"
Lyman Nichols,	"
Sereno D. Nickerson,	"
Otis Norcross,	"
Wm. C. Otis,	"
James W. Paige,	"
Robert T. Paine,	"
Isaac Parker,	"
Theodore Parker,	"
Mrs. S. Parkman,	"
William F. Parrott,	"
A. Peirce, Jr.,	"
Samuel S. Peirce,	"
Thomas W. Peirce,	"
Charles C. Perkins,	"
George Perkins,	"
T. H. Perkins,	"
William Perkins,	"
Jonathan Phillips,	"
Mary Pratt,	"
Sarah P. Pratt,	"
William G. Prescott,	"
William H. Prescott,	"
John Pickering Putnam,	"
Miss Eliza Susan Quincy,	"
Josiah Quincy,	"
Curtis B. Raymond,	"
James Read,	"
B. T. Reed,	"
J. H. Reed,	"
Sampson Reed,	"
George Woods Rice,	"
George C. Richardson,	"
Henry B. Rogers,	"
J. C. Rogers,	"

PART I.

ESSAY ON CLASSIFICATION.

PART III.

EMBRYOLOGY OF THE TURTLE.

CHAPTER 1.

DEVELOPMENT OF THE EGG, FROM ITS FIRST APPEARANCE TO THE FORMATION OF THE EMBRYO.

ESSAY ON CLASSIFICATION.

CHAPTER FIRST.

THE FUNDAMENTAL RELATIONS OF ANIMALS TO ONE ANOTHER AND TO THE WORLD IN WHICH THEY LIVE, AS THE BASIS OF THE NATURAL SYSTEM OF ANIMALS.

SECTION I.

THE LEADING FEATURES OF A NATURAL ZOÖLOGICAL SYSTEM ARE ALL FOUNDED IN NATURE.

MODERN classifications of animals and plants are based upon the peculiarities of their structure; and this is generally considered as the most important, if not the only safe, guide in our attempts to determine the natural relations which exist between animals. This view of the subject seems to me, however, to circumscribe the foundation of a natural system of Zoölogy and Botany within too narrow limits, to exclude from our consideration some of the most striking characteristics of the two organic kingdoms of nature, and to leave it doubtful how far the arrangement thus obtained is founded in reality, and how far it is merely the expression of our estimate of these structural differences. It has appeared to me appropriate, therefore, to present here a short exposition of the leading features of the animal kingdom, as an introduction to the embryology of the Chelonians,—one of the most extraordinary types among Vertebrata,—as it would afford a desirable opportunity of establishing a standard of comparison between the changes animals undergo during their growth, and the permanent characters of full-grown individuals of other types, and, perhaps, of showing also what other points beside structure might with advantage be considered in ascertaining the manifold relations of animals to one another and to the world in which they live, upon which the natural system may be founded.

In considering these various topics, I shall of necessity have to discuss many questions bearing upon the very origin of organized beings, and to touch upon many points now under discussion among scientific men. I shall, however, avoid controversy as much as possible, and only try to render the results of my own studies and meditations in as clear a manner as I possibly can in the short space that I feel justified in devoting to this subject in this volume.

There is no question in Natural History on which more diversified opinions are entertained than on that of Classification; not that naturalists disagree as to the necessity of some sort of arrangement in describing animals or plants, for since nature has become the object of special studies, it has been the universal aim of all naturalists to arrange the objects of their investigations in the most natural order possible. Even Buffon, who began the publication of his great Natural History by denying the existence in nature of any thing like a system, closed his work by grouping the birds according to certain general features, exhibited in common by many of them. It is true, authors have differed in their estimation of the characters on which their different arrangements are founded; and it is equally true that they have not viewed their arrangements in the same light, some having plainly acknowledged the artificial character of their systems, while others have urged theirs as the true expression of the natural relations which exist between the objects themselves. But, whether systems were presented as artificial or natural, they have, to this day, been considered generally as the expression of man's understanding of natural objects, and not as a system devised by the Supreme Intelligence, and manifested in these objects.[1]

There is only one point in these innumerable systems on which all seem to meet, namely, the existence in nature of distinct species, persisting with all their peculiarities, for a time at least; for even the immutability of species has been questioned.[2] Beyond species, however, this confidence in the existence of the divisions, generally admitted in zoölogical systems, diminishes greatly.

With respect to genera, we find already the number of the naturalists who

[1] The expressions constantly used with reference to genera and species and the higher groups in our systems,—as, Mr. A. *has made* such a species *a genus*; Mr. B. *employs* this or that species *to form his genus*; and in which most naturalists indulge when speaking of *their* species, *their* genera, *their* families, *their* systems,—exhibit in an unquestionable light the conviction, that such groups are of their own making; which can, however, only be true in so far as these groups are not true to nature, if the views I shall present below are at all correct.

[2] LAMARCK (J. B. DE) Philosophie zoologique, Paris, 1809, 2 vols. 8vo.; 2de édit., 1830.—POWELL (THE REV. BADEN) Essays on the Spirit of the Inductive Philosophy, etc., London, 1855, 1 vol. 8vo. Compare, also, Sect. 15, below.

accept them as natural divisions much smaller; few of them having expressed a belief that genera have as distinct an existence in nature as species. And as to families, orders, classes, or any kind of higher divisions, they seem to be universally considered as convenient devices, framed with the view of facilitating the study of innumerable objects, and of grouping them in the most suitable manner. The indifference with which this part of our science is generally treated becomes unjustifiable, considering the progress which Zoölogy in general has made of late. It is a matter of consequence, whether genera are circumscribed in our systematic works within these or those limits; whether families inclose a wider or more contracted range of genera; whether such or such orders are admitted in a class, and what are the natural boundaries of classes; as well as how the classes themselves are related to one another, and whether all these groups are considered as resting upon the same foundation in nature or not.

Without venturing here upon an analysis of the various systems of Zoölogy,—the prominent features of which are sufficiently exemplified for my purpose by the systems of Linnæus and Cuvier,[1] which must be familiar to every student of Natural History,—it is certainly a seasonable question to ask, whether the animal kingdom exhibits only those few subdivisions into orders and genera which the Linnæan system indicates, or whether the classes differ among themselves to the extent which the system of Cuvier would lead us to suppose. Or is, after all, this complicated structure of Classification merely an ingenious human invention, which every one may shape, as he pleases, to suit himself? When we remember that all the works on Natural History admit some system or other of this kind, it is certainly an aim worthy of a true naturalist, to ascertain what is the real meaning of all these divisions.

Embryology, moreover, forces the inquiry upon us at every step, as it is impossible to establish precise comparisons between the different stages of growth of young animals of any higher group and the permanent characters of full-grown individuals of other types, without first ascertaining what is the value of the divisions with which we may have to compare embryos. This is my reason for introducing here, in a work chiefly devoted to Embryology, a subject to which I have paid the most careful attention for many years past, and for the solution of which I have made special investigations.

Before I proceed any further, however, I would submit one case to the consideration of my reader. Suppose that the innumerable articulated animals, which are counted by tens of thousands, nay, perhaps by hundreds of thousands, had never made their appearance upon the surface of our globe, with one single exception: that, for instance, our Lobster (Homarus americanus) were the only representative of

[1] Compare Chap. III.

that extraordinarily diversified type,—how should we introduce that species of animals in our systems? Simply as a genus with one species, by the side of all the other classes with their orders, families, etc., or as a family containing only one genus with one species, or as a class with one order and one genus, or as a class with one family and one genus? And should we acknowledge, by the side of Vertebrata, Mollusks, and Radiata, another type of Articulata, on account of the existence of that one Lobster, or would it be natural to call him by a single name, simply as a species, in contradistinction to all other animals? It was the consideration of this supposed case which led me to the investigations detailed below, which, I hope, may end in the ultimate solution of this apparently inextricable question.

Though what I have now to say about this supposed case cannot be fully appreciated before reading my remarks in the following chapter,[1] respecting the character of the different kinds of groups adopted in our systems, it must be obvious that our Lobster, to be what we see these animals are, must have its frame constructed upon that very same plan of structure which it exhibits now; and, if I should succeed in showing that there is a difference between the conception of a plan and the manner of its execution, upon which classes are founded in contradistinction to the types to which they belong, we might arrive at this distinction by a careful investigation of that single Articulate, as well as by the study of all of them; and we might then recognize its types and ascertain its class characters as fully as if the type embraced several classes, and this class thousands of species. Then that animal has a form, which no one would fail to recognize; so that, if form can be shown to be characteristic of families, we could thus determine its family. Again: besides the general structure, showing the fundamental relations of all the systems of organs of the body to one another in their natural development, our investigation could be carried into the study of the details of that structure in every part, and thus lead to the recognition of what constitutes everywhere generic characters. Finally: as this animal has definite relations to the surrounding world, as the individuals living at the time bear definite relations to one another, as the parts of their body show definite proportions, and as the surface of the body exhibits a special ornamentation, the specific characters could be traced as fully as if a number of other species were at hand for comparison; and they might be drawn and described with sufficient accuracy to distinguish it at any future time from any other set of species found afterwards, however closely these new species might be allied to it. In this case, then, we should have to acknowledge a separate branch in the animal kingdom, with a class, a family, and a genus, to introduce one species to its proper place in the system of animals. But the class would have no order, if orders determine the rank, as ascertained by

[1] See Chap. II.

the complication of structure; for, where there is but one representative of a type, there is no room for the question of its superiority or inferiority in comparison to others within the limits of the class, orders being groups subordinate to one another in their class. Yet, even in this case, the question of the standing of Articulata, as a type among the other great branches of the animal kingdom, would be open to our investigations; but it would assume another aspect from that which it now presents, as the comparison of Articulata with the other types would then be limited to the Lobster, and would lead to a very different result from that to which we may arrive, now that this type includes such a large number of most extensively diversified representatives, belonging even to different classes. That such speculations are not idle must be apparent to any one who is aware, that, during every period in the history of our globe in past geological ages,[1] the general relations, the numeric proportions, and the relative importance of all the types of the animal kingdom, have been ever changing, until their present relations were established. Here, then, the individuals of one species, as observed while living, simultaneously exhibit characters, which, to be expressed satisfactorily and in conformity to what nature tells us, would require the establishment, not only of a distinct species, but also of a distinct genus, a distinct family, a distinct class, a distinct branch. Is not this in itself evidence enough that genera, families, orders, classes, and types have the same foundation in nature as species, and that the individuals living at the time have alone a material existence, they being the bearers, not only of all these different categories of structure upon which the natural system of animals is founded, but also of all the relations which animals sustain to the surrounding world,—thus showing that species do not exist in nature in a different way from the higher groups, as is so generally believed?

The divisions of animals according to branch, class, order, family, genus, and species, by which we express the results of our investigations into the relations of the animal kingdom, and which constitute the first question respecting the scientific systems of Natural History which we have to consider, seem to me to deserve the consideration of all thoughtful minds. Are these divisions artificial or natural? Are

[1] A series of classifications of animals and plants, exhibiting each a natural system of the types known to have existed simultaneously during the several successive geological periods, considered singly and without reference to the types of other ages, would show in a strong light the different relations in which the classes, the orders, the families, and even the genera and species, have stood to one another during each epoch. Such classifications would illustrate, in the most impressive manner, the importance of an accurate knowledge of the relative standing of all animals and plants, which can only be inferred from the perusal even of those palæontological works in which fossil remains are illustrated according to their association in different geological formations; for, in all these works, the remains of past ages are uniformly referred to a system established upon the study of the animals now living, thus lessening the impression of their peculiar combination for the periods under consideration.

they the devices of the human mind to classify and arrange our knowledge in such a manner as to bring it more readily within our grasp and facilitate further investigations, or have they been instituted by the Divine Intelligence as the categories of his mode of thinking?[1] Have we, perhaps, thus far been only the unconscious interpreters of a Divine conception, in our attempts to expound nature? and when, in our pride of philosophy, we thought that we were inventing systems of science and classifying creation by the force of our own reason, have we followed only, and reproduced, in our imperfect expressions, the plan whose foundations were laid in the dawn of creation, and the development of which we are laboriously studying,—thinking, as we put together and arrange our fragmentary knowledge, that we are anew introducing order into chaos? Is this order the result of the exertions of human skill and ingenuity, or is it inherent in the objects themselves, so that the intelligent student of Natural History is led unconsciously, by the study of the animal kingdom itself, to these conclusions, the great divisions under which he arranges animals being indeed but the headings to the chapters of the great book which he is reading? To me it appears indisputable, that this order and arrangement of our studies are based upon the natural, primitive relations of animal life,—those systems, to which we have given the names of the great leaders of our science who first proposed them, being in truth but translations, into human language, of the thoughts of the Creator. And if this is indeed so, do we not find in this adaptability of the human intellect to the facts of creation, by which we become instinctively, and, as I have said, unconsciously, the translators of the thoughts of God, the most conclusive proof of our affinity with the Divine Mind? and is not this intellectual and spiritual connection with the Almighty worthy our deepest consideration? If there is any truth in the belief that man is made in the image of God, it is surely not amiss for the philosopher to endeavor, by the study of his own mental operations, to approximate the workings of the Divine Reason, learning, from the nature of his own mind, better to understand the Infinite Intellect from which it is derived. Such a suggestion may, at first sight, appear irreverent. But, which is the truly humble? He who, penetrating into the secrets of creation, arranges them under a formula which he proudly calls his scientific system? or he who, in the same pursuit, recognizes his glorious affinity with the Creator, and, in deepest gratitude for so sublime a birthright, strives to be the faithful interpreter of that Divine Intellect with whom he is permitted, nay, with whom he is intended, according to the laws of his being, to enter into communion?

[1] It must not be overlooked here that a system may be natural, that is, may agree in every respect with the facts in nature, and yet not be considered by its author as the manifestation of the thoughts of a Creator, but merely as the expression of a fact existing in nature, no matter how, which the human mind may trace and reproduce in a systematic form of its own invention.

I confess that this question as to the nature and foundation of our scientific classifications appears to me to have the deepest importance, an importance far greater indeed than is usually attached to it. If it can be proved that man has not invented, but only traced this systematic arrangement in nature, that these relations and proportions which exist throughout the animal and vegetable world have an intellectual, an ideal connection in the mind of the Creator, that this plan of creation, which so commends itself to our highest wisdom, has not grown out of the necessary action of physical laws, but was the free conception of the Almighty Intellect, matured in his thought, before it was manifested in tangible external forms, —if, in short, we can prove premeditation prior to the act of creation, we have done, once and for ever, with the desolate theory which refers us to the laws of matter as accounting for all the wonders of the universe, and leaves us with no God but the monotonous, unvarying action of physical forces, binding all things to their inevitable destiny.[1] I think our science has now reached that degree of advancement, in which we may venture upon such an investigation.

The argument for the existence of an intelligent Creator is generally drawn from

[1] I allude here only to the doctrines of materialists; but I feel it necessary to add, that there are physicists, who might be shocked at the idea of being considered as materialists, who are yet prone to believe that when they have recognized the laws which regulate the physical world, and acknowledged that these laws were established by the Deity, they have explained every thing, even when they have considered only the phenomena of the inorganic world, as if the world contained no living beings and as if these living beings exhibited nothing that differed from the inorganic world. Mistaking for a causal relation the intellectual connection observable between serial phenomena, they are unable to perceive any difference between disorder and the free, independent, and self-possessed action of a superior mind, and call mysticism, even a passing allusion to the existence of an immaterial principle in animals, which they acknowledge themselves in man. [POWELL's Essays, etc., p. 478, 385, and 466.] I would further remark, that, when speaking of creation in contradistinction with reproduction, I mean only to allude to the difference there is between the regular course of phenomena in nature and the establishment of that order of things, without attempting to explain either; for in whatever manner any state of things which has prevailed for a time upon earth may have been introduced, it is self-evident that its establishment and its maintenance for a determined period are two very different things, however frequently they may be mistaken as identical. It is further of itself plain that the laws which may explain the phenomena of the material world, in contradistinction from the organic, cannot be considered as accounting for the existence of living beings, even though these have a material body, unless it be actually shown that the action of these laws implies by their very nature the production of such beings. Thus far, Cross's experiments are the only ones offered as proving such a result. I do not know what physicists may think about them now; but I know that there is scarcely a zoölogist who doubts that they only exhibited a mistake. Life in appropriating the physical world to itself with all its peculiar phenomena exhibits, however, some of its own and of a higher order, which cannot be explained by physical agencies. The circumstance that life is so deeply rooted in the inorganic nature, affords, nevertheless, a strong temptation to explain one by the other; but we shall see presently how fallacious these attempts have been.

the adaptation of means to ends, upon which the Bridgewater treatises, for example, have been based.[1] But this does not appear to me to cover the whole ground, for we can conceive that the natural action of objects upon each other should result in a final fitness of the universe, and thus produce an harmonious whole; nor does the argument derived from the connection of organs and functions seem to me more satisfactory, for, beyond certain limits, it is not even true. We find organs without functions, as, for instance, the teeth of the whale, which never cut through the gum, the breast in all males of the class of mammalia; these and similar organs are preserved in obedience to a certain uniformity of fundamental structure, true to the original formula of that division of animal life, even when not essential to its mode of existence. The organ remains, not for the performance of a function, but with reference to a plan,[2] and might almost remind us of what we often see in human structures, when, for instance, in architecture, the same external combinations are retained for the sake of symmetry and harmony of proportion, even when they have no practical object.

I disclaim every intention of introducing in this work any evidence irrelevant to my subject, or of supporting any conclusions not immediately flowing from it; but I cannot overlook nor disregard here the close connection there is between the facts ascertained by scientific investigations, and the discussions now carried on respecting the origin of organized beings. And though I know those who hold it to be very unscientific to believe that thinking is not something inherent in matter, and that there is an essential difference between inorganic and living and thinking beings, I shall not be prevented by any such pretensions of a false philosophy from expressing

[1] The Bridgewater Treatises, on the Power, Wisdom, and Goodness of God, as Manifested in the Creation: CHALMERS, (THOMAS.) The Adaptation of External Nature to the Moral and Intellectual Constitution of Man, Glasgow, 1839, 2 vols. 8vo.—KIDD, (JOHN.) On the Adaptation of External Nature to the Physical Condition of Man, London, 1833, 1 vol. 8vo.—WHEWELL, (WILL.,) Astronomy and General Physics considered with Reference to Natural Theology, London, 1839, 1 vol. 8vo.—BELL, (CHARLES.) The Hand, its Mechanism and Vital Endowments, as evincing Design, London, 1833, 1 vol. 8vo.—ROGET, (PETER MARK,) Animal and Vegetable Physiology, considered with Reference to Natural Theology, London, 1834, 2 vols. 8vo.—BUCKLAND, (WILL.,) Geology and Mineralogy considered with Reference to Natural Theology, London, 1836, 2 vols. 8vo.; 2d edit. 1837.—KIRBY, (WILL.,) The Power, Wisdom, and Goodness of God, as Manifested in the Creation of Animals, and in their History, Habits, and Instincts, London, 1835, 2 vols. 8vo.—PROUT, (WILL.,) Chemistry, Meteorology, and the Function of Digestion, considered with Reference to Natural Theology, London, 1834, 1 vol. 8vo. Compare also: STRAUSS-DURKHEIM, (HERC.,) Théologie de la Nature, Paris, 1852, 3 vols. 8vo.—MILLER, (HUGH,) Footprints of the Creator, Edinburgh, 1849, 1 vol. 12mo.—BABBAGE, (C.,) The Ninth Bridgewater Treatise, a Fragment, London, 1838, 1 vol. 8vo.; 2d edit.

[2] The unity of structure of the limbs of club-footed or pinnated animals, in which the fingers are never moved, with those which enjoy the most perfect articulations and freedom of motion, exhibits this reference most fully.

my conviction that as long as it cannot be shown that matter or physical forces do actually reason, I shall consider any manifestation of thought as evidence of the existence of a thinking being as the author of such thought, and shall look upon an intelligent and intelligible connection between the facts of nature as direct proof of the existence of a thinking God,[1] as certainly as man exhibits the power of thinking when he recognizes their natural relations.

As I am not writing a didactic work, I will not enter here into a detailed illustration of the facts relating to the various subjects submitted to the consideration of my reader, beyond what is absolutely necessary to follow the argument, nor dwell at any length upon the conclusions to which they lead, but simply recall the leading features of the evidence, assuming in the argument a full acquaintance with the whole range of data upon which it is founded, whether derived from the affinities or the anatomical structure of animals, or from their habits and their geographical distribution, from their embryology, or from their succession in past geological ages, and the peculiarities they have exhibited during each,[2] believing, as I do, that isolated and disconnected facts are of little consequence in the contemplation of the whole plan

[1] I am well aware that even the most eminent investigators consider the task of science at an end, as soon as the most general relations of natural phenomena have been ascertained. To many the inquiry into the primitive cause of their existence seems either beyond the reach of man, or as belonging rather to philosophy than to physics. To these the name of God appears out of place in a scientific work, as if the knowledge of secondary agencies constituted alone a worthy subject for their investigations, and as if nature could teach nothing about its Author. Many, again, are no doubt prevented from expressing their conviction that the world was called into existence and is regulated by an intelligent God, either by the fear of being supposed to share clerical or sectarian prejudices; or because it may be dangerous for them to discuss freely such questions without acknowledging at the same time the obligation of taking the Old Testament as the standard by which the validity of their results is to be measured. Science, however, can only pro-per when confining itself within its legitimate sphere; and nothing can be more detrimental to its true dignity than discussions like those which took place at the last meeting of the German association of naturalists, in Göttingen, and which have since then been carried on in several pamphlets in which bigotry vies with personality and invective.

[2] Many points little investigated thus far by most naturalists, but to which I have of late years paid particular attention, are here presented only in an aphoristic form, as results established by extensive investigations, though unpublished, most of which will be fully illustrated in my following volumes, or in a special work upon the plan of the creation. (See Agassiz, (L.) On the Difference between Progressive, Embryonic, and Prophetic Types in the Succession of Organized Beings, Proceed. 2d Meeting Amer. Assoc. for the Advancement of Science, held at Cambridge in 1849, Boston, 1850, 1 vol. 8vo., p. 432.) Meanwhile I refer in foot notes to such works as contain the materials already on hand for the discussion of these subjects, even when presented in a different light. I would only beg leave to add, that in these references I have by no means attempted to quote all the writers upon the various topics under consideration, but only the most prominent and most instructive, and here and there some condensed accounts of the facts in more elementary works, by the side of the original papers.

of creation, and that without a consideration of all the facts furnished by the study of the habits of animals, by their anatomy, their embryology, and the history of the past ages of our globe, we shall never arrive at the knowledge of the natural system of animals.

Let us now consider some of these topics more specially.

SECTION II.

SIMULTANEOUS EXISTENCE OF THE MOST DIVERSIFIED TYPES UNDER IDENTICAL CIRCUMSTANCES.

It is a fact which seems to be entirely overlooked by those who assume an extensive influence of physical causes upon the very existence of organized beings, that the most diversified types of animals and plants are everywhere found under identical circumstances. The smallest sheet of fresh water, every point upon the sea-shore, every acre of dry land, teems with a variety of animals and plants. The narrower the boundaries are, which may be assigned as the primitive home of all these beings, the more uniform must be the conditions under which they are assumed to have originated; so uniform, indeed, that in the end the inference would be, that the same physical causes could produce the most diversified effects.[1] To concede,

[1] In order fully to appreciate the difficulty alluded to here, it is only necessary to remember how complicated, and at the same time how localized the conditions are under which animals multiply. The egg originates in a special organ, the ovary; it grows there to a certain size, until it requires fecundation, that is, the influence of another living being, or at least of the product of another organ, the spermary, to determine the further development of the germ, which, under the most diversified conditions, in different species, passes successively through all those changes which lead to the formation of a new perfect being. I then would ask, is it probable that the circumstances under which animals and plants originated for the first time can be much simpler, or even as simple, as the conditions necessary for their reproduction only, after they have once been created? Preliminary, then, to their first appearance, the conditions necessary for their growth must have been provided for, if, as I believe, they were created as eggs, which conditions must have been conformable to those in which the living representatives of the types first produced, now reproduce themselves. If it were assumed that they originated in a more advanced stage of life, the difficulties would be still greater, as a moment's consideration cannot fail to show, especially if it is remembered how complicated the structure of some of the animals was, which are known to have been among the first inhabitants of our globe. When investigating this subject, it is of course necessary to consider the first appearance of animals and plants, upon the basis of probabilities only, or even simply upon that of possibilities; as with reference to these first-born, at least, the transmutation theory furnishes no explanation of their existence.

For every species belonging to the first fauna and the first flora which have existed upon earth, special on the contrary, that these organisms may have appeared in the beginning over a wide area, is to grant, at the same time, that the physical influences under which they existed at first were not so specific as to justify the assumption that these could be the cause of their appearance. In whatever connection, then, the first appearance of organized beings upon earth is viewed, whether it is assumed that they originated within the most limited areas, or over the widest range of their present natural geographical distribution, animals and plants being everywhere diversified to the most extraordinary extent, it is plain that the physical influences under which they subsist cannot logically be considered as the cause of that diversity. In this, as in every other respect, when considering the relations of animals and plants to the conditions under which they live, or to one another, we are inevitably led to look beyond the material facts of the case for an explanation of their existence. Those who have taken another view of this subject, have mistaken the action and reaction which exist everywhere between organized beings, and the physical influences under which they live[1] for a causal or genetic connection, and carried their mistake so far as to assert that these manifold influences could really extend to the production of these beings, not considering how inadequate such a cause would be, and that even the action of physical agents upon organized beings presupposes the very existence of those beings.[2] The simple fact that there has been a period in the history

relations, special contrivances must therefore have been provided. Now, what would be appropriate for the one, would not suit the other, so that excluding one another in this way, they cannot have originated upon the same point; while within a wider area, physical agents are too uniform in their mode of action to have laid the foundation for so many such specific differences as existed between the first inhabitants of our globe.

[1] See, below, Sect. 16.

[2] A critical examination of this point may dispel much of the confusion which prevails in the discussions relating to the influence of physical causes upon organized beings. That there exist definite relations between animals as well as plants and the mediums in which they live, no one at all familiar with the phenomena of the organic world can doubt; that these mediums and all physical agents at work in nature, have a certain influence upon organized beings is equally plain. But before any such action can take place and be felt, organized beings must exist. The problem before us involves, therefore, two questions, the influence of physical agents upon animals and plants already in existence, and the origin of these beings. Granting the influence of these agents upon organized beings to the fullest extent to which it may be traced, (see Sect. 16,) there remains still the question of their origin upon which neither argument nor observation has yet thrown any light. But according to some, they originated spontaneously by the immediate agency of physical forces, and have become successively more and more diversified by changes produced gradually upon them, by these same forces. Others believe that there exist laws in nature which were established by the Deity in the beginning, to the action of which the origin of organized beings may be ascribed; while according to others, they owe their existence to the immediate intervention of an intelligent Creator. It is the object of the following paragraphs to show that there are neither agents nor laws in nature known to physicists under the influence and by the action of which these beings could have originated: that, on the contrary, the very nature of these be-

of our earth, now well known to geologists,[1] when none of these organized beings as yet existed, and when, nevertheless, the material constitution of our globe, and the physical forces acting upon it, were essentially the same as they are now,[2] shows that these influences are insufficient to call into existence any living being.

Physicists know, indeed, these physical agents more accurately than the naturalists, who ascribe to them the origin of organized beings; let us then ask them, whether the nature of these agents is not specific, whether their mode of action is not specific? They will all answer, that they are. Let us further inquire of them, what evidence there is, in the present state of our knowledge, that at any time these physical agents have produced any thing they no longer do produce, and what probability there is that they may ever have produced any organized being? If I am not greatly mistaken, the masters in that department of science will, one and all, answer, none whatever.

But the character of the connections between organized beings and the physical conditions under which they live is such as to display thought;[3] these connections are therefore to be considered as established, determined, and regulated by a thinking being. They must have been fixed for each species at its beginning, while the fact of their permanency through successive generations[4] is further evidence that with their natural relations to the surrounding world were also determined the relations of individuals to one another,[5] their generic as well as their family relations, and every higher grade of affinity,[6] showing, therefore, not only thought, in reference to the physical conditions of existence, but such comprehensive thoughts as would embrace simultaneously every characteristic of each species.

Every fact relating to the geographical distribution of animals and plants might be alluded to in confirmation of this argument, but especially the character of every

ings, and their relations to one another and to the world in which they live, exhibit thought, and can therefore be referred only to the immediate action of a thinking being, even though the manner in which they were called into existence remains for the present a mystery.

[1] Few geologists only may now be inclined to believe that the lowest strata known to contain fossils, are not the lowest deposits formed since the existence of organized beings upon earth. But even those who would assume that still lower fossiliferous beds may yet be discovered, or may have entirely disappeared by the influence of plutonic agencies, (POWELL'S Essays, etc., p. 424,) must acknowledge the fact that everywhere in the lowest rocks known to contain fossils at all, there is a variety of them found together. (See Sect. 7.) Moreover, the similarity in the character of the oldest fossils found in different parts of the world, goes far, in my opinion, to prove that we actually do know the earliest types of the animal kingdom which have inhabited our globe. This conclusion seems fully sustained by the fact that we find everywhere below this oldest set of fossiliferous beds, other stratified rocks in which no trace of organized beings can be found.

[2] See, below, Sect. 21.

[3] See, below, Sect. 16.

[4] See, below, Sect. 15.

[5] See, below, Sect. 17.

[6] See, below, Sect. 6.

fauna and every flora upon the surface of the globe. How great the diversity of animals and plants living together in the same region may be, can be ascertained by the perusal of special works upon the Zoölogy and Botany of different countries, or from special treatises upon the geographical distribution of animals and plants.[1] I need, therefore, not enter into further details upon this subject, especially since it is discussed more fully below.[2]

It might, perhaps, be urged, that animals living together in exceptional conditions, and exhibiting structural peculiarities apparently resulting from these conditions, such as the blind fish,[3] the blind crawfish, and the blind insects of the Mammoth Cave in Kentucky, furnish uncontrovertible evidence of the immediate influence of those exceptional conditions upon the organs of vision. If this, however, were the case, how does it happen that that remarkable fish, the *Amblyopsis spelæus*, has only such remote affinities to other fishes? Or were, perhaps, the sum of influences at work to make that fish blind, capable also of devising such a combination of structural characters as that fish has in common with all other fishes, with those peculiarities which at the same time distinguish it? Does not, rather, the existence of a rudimentary eye discovered by Dr. J. Wyman in the blind fish show, that these animals, like all others, were created with all their peculiarities by the fiat of the Almighty, and this rudiment of eyes left them as a remembrance of the general plan of structure of the great type to which they belong? Or will, perhaps, some one of those naturalists who know so much better than the physicists what physical forces may produce, and that they may produce, and have produced every living being known, explain also to us why subterraneous caves in America produce blind fishes, blind crustacea, and blind insects, while in Europe they produce nearly blind reptiles? If there is no thought in the case, why is it, then, that this very reptile, the *Proteus anguinus*, forms, with a number of other reptiles living in North America and in Japan, one of

[1] SCHMARDA, Die geographische Verbreitung der Thiere, 3 vols. 8vo. Wien, 1853.—SWAINSON, (W.) A Treatise on the Geography and Classification of Animals, London, 1835, 1 vol. 12mo.—ZIMMERMANN, (E. A. G.) Specimen Zoologiæ geographicæ, Quadrupedum domicilia et migrationes sistens, Lugduni-Batav., 1777, 1 vol. 4to.—HUMBOLDT, Essai sur la géographie des plantes, 4to., Paris, 1805; and Ansichten der Natur, 3d edit., 12mo., Stuttgardt and Tübingen, 1849.—ROBERT BROWN, General Remarks on the Botany of Terra Australis, London, 1814.—SCHOUW, Grundzüge einer allgemeinen Pflanzengeographie, 1 vol. 8vo., with atlas in fol., Berlin, 1823.—ALPH. DE CANDOLLE, Géographie botanique raisonnée, 2 vols. 8vo., Paris, 1855. References to special works may be found below, Sect. 9.

[2] See, below, Sect. 9.

[3] WYMAN, (JEF.) Description of a Blind Fish, from a Cave in Kentucky, SILLIMAN's Jour., 1843, vol. 45, p. 94, and 1854, vol. 17, p. 258.—TELLKAMPF, (TH. G.) Ueber den blinden Fisch der Mammuthhöhle in Kentucky, in MÜLLER's Archiv, 1844, p. 381.—TELLKAMPF, (TH. G.) Beschreibung einiger neuer in der Mammuthhöhle aufgefundener Gattungen von Gliederthieren, WIEGMAN's Archiv, 1844, vol. I., p. 318.—AGASSIZ, (L.) Observations on the Blind Fish of the Mammoth Cave, SILLIMAN's Journal, 1851, vol. 11, p. 127.

the most natural series known in the animal kingdom, every member of which exhibits a distinct grade [1] in the scale?

After we have freed ourselves from the mistaken impression that there may be some genetic connection between physical forces and organized beings, there remains a vast field of investigation to ascertain the true relations between both, to their full extent, and within their natural limits.[2] A mere reference to the mode of breathing of different types of animals, and to their organs of locomotion, which are more particularly concerned in these relations, will remind every naturalist of how great importance in classification is the structure of these parts, and how much better they might be understood in this point of view, were the different structures of these organs more extensively studied in their direct reference to the world in which animals live. If this had been done, we should no longer call by the same common name of legs and wings organs so different as the locomotive appendages of the insects and those of the birds? We should no longer call lungs the breathing cavity of snails, as well as the air pipes of mammalia, birds, and reptiles? A great reform is indeed needed in this part of our science, and no study can prepare us better for it than the investigation of the mutual dependence of the structure of animals, and the conditions in which they live.

SECTION III.

REPETITION OF IDENTICAL TYPES UNDER THE MOST DIVERSIFIED CIRCUMSTANCES.

As much as the diversity of animals and plants living under identical physical conditions, shows the independence of organized beings from the medium in which they dwell, so far as their origin is concerned, so independent do they appear again from the same influences when we consider the fact that identical types occur everywhere upon earth under the most diversified circumstances. If we sum up all these various influences and conditions of existence under the common appellation of cosmic influences, or of physical causes, or of climate in the widest sense of the word, and then look around us for the extreme differences in that respect upon the whole surface of the globe, we find still the most similar, nay identical types (and I allude here, under the expression of type, to the most diversified acceptations of the word) living normally under their action. There is no structural difference between the herrings of the Arctic, or those of the Temperate zone, or those of the Tropics,

[1] See, below, Sect. 12.

[2] See, below, Sect. 16.

or those of the Antarctic regions; there are not any more between the foxes and wolves of the most distant parts of the globe.[1] Moreover, if there were any, and the specific differences existing between them were insisted upon, could any relation between these differences and the cosmic influences under which they live be pointed out, which would at the same time account for the independence of their structure in general? Or, in other words, how could it be assumed that while these causes would produce specific differences, they would at the same time produce generic identity, family identity, ordinal identity, class identity, typical identity? Identity in every thing that is truly important, high, and complicated in the structure of animals, produced by the most diversified influences, while at the same time these extreme physical differences, considered as the cause of the existence of these animals, would produce diversity in secondary relations only! What logic!

Does not all this show, on the contrary, that organized beings exhibit the most astonishing independence of the physical causes under which they live; an independence so great that it can only be understood as the result of a power governing these physical causes as well as the existence of animals and plants, and bringing all into harmonious relations by adaptations which never can be considered as cause and effect?

When naturalists have investigated the influence of physical causes upon living beings, they have constantly overlooked the fact that the features which are thus modified are only of secondary importance in the life of animals and plants, and that neither the plan of their structure, nor the various complications of that structure, are ever affected by such influences. What, indeed, are the parts of the body which are, in any way, affected by external influences? Chiefly those which are in immediate contact with the external world, such as the skin, and in the skin chiefly its outer layers, its color, the thickness of the fur, the color of the hair, the feathers, and the scales; then the size of the body and its weight, as far as it is dependent on the quality and quantity of the food; the thickness of the shell of Mollusks, when they live in waters or upon a soil containing more or less limestone, etc. The rapidity or slowness of the growth is also influenced in a measure by the course of the seasons, in different years; so is also the fecundity, the duration of life, etc. But all this has nothing to do with the essential characteristics of animals.

A book has yet to be written upon the independence of organized beings of physical causes, as most of what is generally ascribed to the influence of physical agents upon organized beings ought to be considered as a connection established between them in the general plan of creation.

[1] Innumerable other examples might be quoted, which will readily present themselves to professional naturalists; those mentioned above may suffice for my argument.

SECTION IV.

UNITY OF PLAN IN OTHERWISE HIGHLY DIVERSIFIED TYPES.

Nothing is more striking throughout the animal and vegetable kingdoms than the unity of plan in the structure of the most diversified types. From pole to pole, in every longitude, mammalia, birds, reptiles, and fishes, exhibit one and the same plan of structure,[1] involving abstract conceptions of the highest order, far transcending the broadest generalizations of man, for it is only after the most laborious investigations man has arrived at an imperfect understanding of this plan. Other plans, equally wonderful, may be traced in Articulata, in Mollusks, in Radiata,[2] and in the various types of plants,[3] and yet this logical connection, these beautiful harmonies, this infinite diversity in unity are represented by some as the result of forces exhibiting no trace of intelligence, no power of thinking, no faculty of combination, no knowledge of time and space. If there is any thing which places man above all other beings in nature, it is precisely the circumstance that he possesses those noble attributes without which, in their most exalted excellence and perfection, not one of these

[1] With reference to this point, consult: OKEN, (LOR.,) Ueber die Bedeutung der Schädel-Knochen, Frankfort, 1807, 4to. (pamphlet.)—SPIX, (J. B.) Cephalogenesis, sive capitis ossei structura, formatio et significatio, Monachii, 1815, fol.—GEOFFROY ST. HILAIRE, (ET.,) Philosophie anatomique, Paris, 1818–1823, 2 vols. 8vo., and several papers in the Annal. des sc. nat., Annal. and Mém. du Muséum, etc.—CARUS, (C. G.,) Von den Ur-Theilen des Knochen- und Schalengerüstes, Leipzig, 1828, fol.—OWEN, (R.) On the Archetype and Homologies of the Vertebrate Skeleton, London, 1848, 8vo.

[2] OKEN, (LOR.,) Lehrbuch der Naturphilosophie, Jena, 1809–11, 3 vols. 8vo.; Engl. Elements of Physio-philosophy, Ray Society, London, 1847, 8vo.—CUVIER, (G.,) Sur un nouveau rapprochement à établir entre les classes qui composent le Règne Animal, Annales du Muséum, vol. xix., 1812.—SAVIGNY, (J. C.,) Mémoires sur les animaux sans vertèbres, Paris, 1816, 8vo.—BAER, (C. E. v.,) Ueber Entwickelungsgeschichte der Thiere, Königsberg, 1828, 4to.—LEUKARDT, (R.,) Ueber die Morphologie und die Verwandtschaftsverhältnisse der wirbellosen Thiere, Braunschweig, 1848, 8vo.—AGASSIZ, (L.,) Twelve Lectures on Comparative Embryology, Boston, 1849, 8vo.—On Animal Morphology, Proc. Amer. Assoc. for the Adv. of Science, Boston, 1850, 8vo., p. 411. I would call particular attention to this paper, which has immediate reference to the subject of this chapter.—CARUS, (V.,) System der thierischen Morphologie, Leipzig, 1853, 1 vol. 8vo.

[3] GÖTHE, (J. W.,) Zur Naturwissenchaft überhaupt, besonders zur Morphologie, Stuttgardt, 1817–24, 2 vols. 8vo.; French, Oeuvres d'histoire naturelle, comprenant divers mémoires d'Anatomie comparée, de Botanique et de Géologie, traduits et annotés par Ch. Fr. Martins, Paris, 1837, 8vo.: atlas in fol.—DECANDOLLE, (A. P.) Organographie végétale, Paris, 1827, 2 vols. 8vo.—BRAUN, (AL.,) Vergleichende Untersuchung über die Ordnung der Schuppen an den Tannenzapfen, als Einleitung zur Untersuchung der Blattstellung überhaupt, Act. Nov. Ac. Nat. Curios., vol. xv., 1829.—Das Individuum der Pflanze, Akad. d. Wiss., Berlin, 1853, 4to.

general traits of relationship so characteristic of the great types of the animal and vegetable kingdoms, can be understood, or even perceived. How, then, could these relations have been devised without similar powers? If all these relations are almost beyond the reach of the mental powers of man, and if man himself is part and parcel of the whole system, how could this system have been called into existence if there does not exist One Supreme Intelligence, as the Author of all things?

SECTION V.

CORRESPONDENCE IN THE DETAILS OF STRUCTURE IN ANIMALS OTHERWISE ENTIRELY DISCONNECTED.

During the first decade of this century, naturalists began to study relations among animals which had escaped almost entirely the attention of earlier observers. Though Aristotle knew already that the scales of fishes correspond to the feathers of birds,[1] it is but recently that anatomists have discovered the close correspondence which exists between all the parts of all animals belonging to the same type, however different they may appear at first sight. Not only is the wing of the bird identical in its structure with the arm of man, or the fore leg of a quadruped, it agrees quite as closely with the fin of the whale, or the pectoral fin of the fish, and all these together correspond in the same manner with their hind extremities. Quite as striking a coincidence is observed between the solid skull-box, the immovable bones of the face and the lower jaw of man and the other mammalia, and the structure of the bony frame of the head of birds, turtles, lizards, snakes, frogs, and fishes. But this correspondence is not limited to the skeleton; every other system of organs exhibits in these animals the same relations, the same identity in plan and structure, whatever be the differences in the form of the parts, in their number, and even in their functions. Such an agreement in the structure of animals is called their homology, and is more or less close in proportion as the animals in which it is traced are more or less nearly related.

The same agreement exists between the different systems and their parts in Articulata, in Mollusks, and in Radiata, only that their structure is built up upon respectively different plans, though in these three types the homologies have not yet been traced to the same extent as among Vertebrata. There is therefore still a wide

[1] ARISTOTELES, Historia Animalium, Lib. I., Chap. 1, Sect. 4. ὃ γὰρ ἐν ὄρνιθι πτερὸν, τοῦτο ἐν ἰχθύϊ ἐστὶ λεπίς.—Consult also the authors referred to in Sect. 4, notes 1 and 2, and the many other works, pamphlets, and papers, quoted by them, which are too numerous to be mentioned here.

field open for investigations in this most attractive branch of Zoölogy. So much, however, is already plain from what has been done in this department of our science, that the identity of structure among animals does not extend to all the four branches of the animal kingdom; that, on the contrary, every great type is constructed upon a distinct plan, so peculiar, indeed, that homologies cannot be extended from one type to the other, but are strictly limited within each of them. The more remote resemblance which may be traced between representatives of different types, is founded upon analogy,[1] and not upon affinity. While, for instance, the head of fishes exhibits the most striking homology with that of reptiles, birds, and mammalia, as a whole, as well as in all its parts, that of Articulata is only analogous to it and to its part. What is commonly called head in Insects is not a head like that of Vertebrata; it has not a distinct cavity for the brain, separated from that which communicates below the neck with the chest and abdomen; its solid envelope does not consist of parts of an internal skeleton, surrounded by flesh, but is formed of external rings, like those of the body, soldered together; it contains but one cavity, which includes the cephalic ganglion, as well as the organs of the mouth, and all the muscles of the head. The same may be said of the chest, the legs and wings, the abdomen, and all the parts they contain. The cephalic ganglion is not homologous to the brain, nor are the organs of senses homologous to those of Vertebrata, even though they perform the same functions. The alimentary canal is formed in a very different way in the embryos of the two types, as are also their respiratory organs, and it is as unnatural to identify them, as it would be still to consider gills and lungs as homologous among Vertebrata now embryology has taught us that in different stages of growth these two kinds of respiratory organs exist in all Vertebrata in very different organic connections one from the other.

What is true of the branch of Articulata when compared to that of Vertebrata, is equally true of the Mollusks and Radiata when compared with one another or with the two other types, as might easily be shown by a fuller illustration of the correspondence of their structure, within these limits. This inequality in the fundamental character of the structure of the four branches of the animal kingdom points to the necessity of a radical reform in the nomenclature of comparative anatomy.[2] Some naturalists, however, have already extended such comparisons respecting the structure of animals beyond the limits pointed out by nature, when they have attempted to show that all structures may be reduced to one norm, and

[1] See SWAINSON, (W.,) On the Geography and Classification of Animals, London, 1835, 12mo., p. 129, where this point is ably discussed.

[2] See AGASSIZ, (L.,) On the Structure and Homologies of Radiated Animals, with Reference to the Systematic Position of the Hydroid Polypi, Proc. of the Amer. Assoc. for the Adv. of Science for 1849, Boston, 1850, 1 vol. 8vo. p. 389.

when they have maintained, for instance, that every bone existing in any Vertebrate must have its counterpart in every other species of that type. To assume such a uniformity among animals, would amount to denying to the Creator even as much freedom in expressing his thoughts as man enjoys.

If it be true, as pointed out above, that all animals are constructed upon four different plans of structure, in such a manner that all the different kinds of animals are only different expressions of these fundamental formulæ, we may well compare the whole animal kingdom to a work illustrating four great ideas, between which there is no other connecting link than the unity exhibited in the eggs in which their most diversified manifestations are first embodied in an embryonic form, to undergo a series of transformations, and appear in the end in that wonderful variety of independent living beings which inhabit our globe, or have inhabited it from the earliest period of the existence of life upon its surface.

The most surprising feature of the animal kingdom seems, however, to me to rest neither in its diversity, nor in the various degrees of complication of its structure, nor in the close affinity of some of its representatives, while others are so different, nor in the manifold relations of all of them to one another and the surrounding world, but in the circumstance that beings endowed with such different and such unequal gifts should nevertheless constitute an harmonious whole, intelligibly connected in all its parts.

SECTION VI.

VARIOUS DEGREES AND DIFFERENT KINDS OF RELATIONSHIP AMONG ANIMALS.

The degrees of relationship existing between different animals are most diversified. They are not only akin as representatives of the same species, bearing as such the closest resemblance to one another; different species may also be related as members of the same genus, the representatives of different genera may belong to the same family, and the same order may contain different families, the same class different orders, and the same type several classes. The existence of different degrees of affinity between animals and plants which have not the remotest genealogical connection, which live in the most distant parts of the world, which have existed in periods long gone by in the history of our earth, is a fact beyond dispute, at least, within certain limits, no longer controverted by well informed observers. Upon what can this be founded? Is it that the retentive capacity of the memory of the physical forces at work upon this globe is such, that after bringing forth a type according to one pattern, in the infancy of this earth, that pattern was adhered to under conditions, no matter how diversified, to reproduce, at another period, something similar, and so on, through all ages, until at the period of the establishment of the present state of things, all the infinitude of new animals and new plants which now crowd its surface, should be cast in these four moulds, in such a manner as to exhibit, notwithstanding their complicated relations to the surrounding world, all those more deeply seated general relations, which establish among them the different degrees of affinity we may trace so readily in all the representatives of the same type? Does all this really look more like the working of blind forces than like the creation of a reflective mind establishing deliberately all the categories of existence we recognize in nature, and combining them in that wonderful harmony which unites all things into such a perfect system, that even to read it, as it is established, or even with all the imperfections of a translation, should be considered as the highest achievement of the maturest genius?

Nothing seems to me to prove more directly and more fully the action of a reflective mind, to indicate more plainly a deliberate consideration of the subject, than the different categories upon which species, genera, families, orders, classes, and branches are founded in nature, and manifested in material reality in a succession of individuals, the life of which is limited in its duration to comparatively very short periods. The great wonder in these relations consists in the fugitive character of the bearers of this complicated harmony. For while species persist during long periods, the individuals which represent them are ever changing, one set dying after the other, in quick succession. Genera, it is true, may extend over longer periods; families, orders, and classes may even have existed during all periods during which animals have existed at all; but whatever may have been the duration of their existence, at all times these different divisions have stood in the same relation to one another and to their respective branches, and have always been represented upon our globe in the same manner, by a succession of ever renewed and short-lived individuals.

As, however, the second chapter of this work is entirely devoted to the consideration of the different kinds and the different degrees of affinity existing among animals, I will not enter here into any details upon this subject, but simply recall the fact that, in the course of time, investigators have agreed more and more with one another in their estimates of these relations, and built up systems more and more conformable to one another. This result, which is fully exemplified by the history of our science,[1] is in itself sufficient to show that there is a system in nature

[1] SPIX, (J.,) Geschichte und Beurtheilung aller Systeme in der Zoologie, Nürnberg, 1811, 1 vol. 8vo. — CUVIER, (G.,) Histoire des progrès des sciences naturelles, Paris, 1826, 4 vols. 8vo. — Histoire des sciences naturelles, etc., Paris, 1841, 5 vols. 8vo. — DEBLAINVILLE, (H.,) Histoire des sciences de

to which the different systems of authors are successive approximations, more and more closely agreeing with it, in proportion as the human mind has understood nature better. This growing coincidence between our systems and that of nature shows further the identity of the operations of the human and the Divine intellect; especially when it is remembered to what an extraordinary degree many *à priori* conceptions, relating to nature, have in the end proved to agree with the reality, in spite of every objection at first offered by empiric observers.

SECTION VII.

SIMULTANEOUS EXISTENCE IN THE EARLIEST GEOLOGICAL PERIODS, OF ALL THE GREAT TYPES OF ANIMALS.

It was formerly believed by geologists and palæontologists that the lowest animals first made their appearance upon this globe, and that they were followed by higher and higher types, until man crowned the series. Every geological museum, representing at all the present state of our knowledge, may now furnish the evidence that this is not the case. On the contrary, representatives of numerous families belonging to all the four great branches of the animal kingdom, are well known to have existed simultaneously in the oldest geological formations.[1] Nevertheless, I well remember when I used to hear the great geologists of the time assert, that the Corals were the first inhabitants of our globe, that Mollusks and Articulata followed in order, and that Vertebrates did not appear until long after these. What an extraordinary change the last thirty years have brought about in our knowledge, and the doctrines generally adopted respecting the existence of animals and plants in past ages! However much naturalists may still differ in their views regarding the origin, the gradation, and the affinities of animals, they now all know that neither Radiata, nor Mollusks, nor Articulata, have any priority one over the other, as to the time

l'organisation et de leurs progrès, Paris, 1847, 3 vols. 8vo. — POUCHET, (F. A.,) Histoire des sciences naturelles au moyen âge, Paris, 1853, 1 vol. 8vo. Compare, also, Chap. II., below.

[1] MURCHISON, (R. I.,) The Silurian System, London, 1839, 1 vol. 4to. — MURCHISON, (SIR R. I.,) Siluria. The History of the Oldest Known Rocks containing Fossils, London, 1854, 1 vol. 8vo. — MURCHISON, (R. I.,) DE VERNEUIL, (ED.,) and KAISERLING, (COUNT ALEX. VON,) The Geology of Russia in Europe, and the Ural Mountains, London, 1845, 2 vols. 4to. — HALL, (JAMES,) Palæontology of New York, Albany, 1847–52, 2 vols. 4to. — BARRANDE, (J.,) Système silurien du centre de la Bohème, Prague and Paris, 1852, 2 vols. 4to. — SEDGWICK, (A.,) and McKOY, (FR.,) British Palæozoic Rocks and Fossils, London, 1851, 4to. 2 fasc.; not yet complete.

of their first appearance upon earth; and though some still maintain that Vertebrata originated somewhat later, it is universally conceded that they were already in existence toward the end of the first great epoch in the history of our globe. I think it would not be difficult to show upon physiological grounds that their presence upon earth dates from as early a period as any of the three other great types of the animal kingdom, since fishes exist wherever Radiata, Mollusks, and Articulata are found together, and the plan of structure of these four great types constitutes a system intimately connected in its very essence. Moreover, for the last twenty years, every extensive investigation among the oldest fossiliferous rocks has carried the origin of Vertebrata step by step further back, so that whatever may be the final solution of this vexed question, so much is already established by innumerable facts, that the idea of a gradual succession of Radiata, Mollusks, Articulata, and Vertebrata, is for ever out of the question. It is proved beyond doubt, that Radiata, Mollusca, and Articulata are everywhere found together in the oldest geological formations, and that very early Vertebrata are associated with them, to continue together through all geological ages to the present time. This shows that even in those early days of the existence of our globe, when its surface did not yet present those diversified features which it has exhibited in later periods, and which it exhibits in still greater variety now, animals belonging to all the great types now represented upon earth, were simultaneously called into existence. It shows, further, that unless the physical elements then at work could have devised such plans, and impressed them upon the material world as the pattern upon which Nature was to build for ever afterwards, no such general relations as exist among all animals, of all geological periods, as well as among those now living, could ever have existed.

This is not all: every class among Radiata, Mollusks, and Articulata, is known to have been represented in those earliest days, with the exception of the Acalephs[1] and Insects only. It is, therefore, not only the plan of the four great types which must have been adopted then, the manner in which these plans were to be executed, the systems of form under which these structures were to be clothed, even the ultimate details of structure which in different genera bear definite relations to those of other genera; the mode of differentiation of species, and the nature of their relations to the surrounding media, must likewise have been determined, as the character of the classes is as well defined as that of the four great branches of the animal kingdom, or that of the families, the genera, and the species. Again, the first representatives of each class stand in definite relations to their successors in later

[1] Acalephs have been found in the Jurassic Limestone of Solenhofen; their absence in other formations may be owing simply to the extraordinary softness of their body. Insects are known as early as the Carboniferous Formation, and may have existed before.

periods, and as their order of apparition corresponds to the various degrees of complication in their structure, and forms natural series closely linked together, this natural gradation must have been contemplated from the very beginning. There can be the less doubt upon this point, as man, who comes last, closes in his own cycle a series, the gradation of which points from the very beginning to him as its last term. I think it can be shown by anatomical evidence that man is not only the last and highest among the living beings, for the present period, but that he is the last term of a series beyond which there is no material progress possible upon the plan upon which the whole animal kingdom is constructed, and that the only improvement we may look to upon earth, for the future, must consist in the development of man's intellectual and moral faculties.[1]

The question has been raised of late how far the oldest fossils known may truly be the remains of the first inhabitants of our globe. No doubt extensive tracts of fossiliferous rocks have been intensely altered by plutonic agencies, and their organic contents so entirely destroyed, and the rocks themselves so deeply metamorphosed, that they resemble now more closely eruptive rocks even than stratified deposits. Such changes have taken place again and again up to comparatively recent periods, and upon a very large scale. Yet there are entire continents, North America, for instance, in which the palæozoic rocks have undergone little, if any, alteration, and where the remains of the earliest representatives of the animal and vegetable kingdoms are as well preserved as in later formations. In such deposits the evidence is satisfactory that a variety of animals belonging to different classes of the great branches of the animal kingdom have existed simultaneously from the beginning; so that the assumption of a successive introduction of these types upon earth is flatly contradicted by well established and well known facts.[2] Moreover, the remains found in the oldest deposits, are everywhere closely allied to one another. In Russia, in Sweden, in Bohemia, and in various other parts of the world, where these oldest formations have been altered upon a more or less extensive scale, as well as in North America, where they have undergone little or no change, they present the same general character, that close correspondence in their structure and in the combination of their families, which shows them to have belonged to contemporaneous faunæ. It would, therefore, seem that even where metamorphic rocks prevail, the traces of the earliest inhabitants of this globe have not been entirely obliterated.

[1] AGASSIZ, (L.,) An Introduction to the Study of Natural History, New York, 1847, 8vo. p. 57.

[2] AGASSIZ, (L.,) The Primitive Diversity and Number of Animals in Geological Times, Amer. Journ. of Science and Arts, 2d ser., vol. 17, 1854, p. 309.

SECTION VIII.

THE GRADATION OF STRUCTURE AMONG ANIMALS.

There is not only variety among animals and plants; they differ also as to their standing, their rank, their superiority or inferiority when compared to one another. But this rank is difficult to determine; for while, in some respects, all animals are equally perfect, as they perform completely the part assigned to them in the general economy of nature,[1] in other respects there are such striking differences between them, that their very agreement in certain features points at their superiority or inferiority in regard to others.

This being the case, the question first arises, Do all animals form one unbroken series from the lowest to the highest? Before the animal kingdom had been studied so closely as it has been of late, many able writers really believed that all animals formed but one simple continuous series, the gradation of which Bonnet has been particularly industrious in trying to ascertain.[2] At a later period, Lamarck[3] has endeavored to show further, that in the complication of their structure, all the classes of the animal kingdom represent only successive degrees, and he is so thoroughly convinced that in his systematic arrangement classes constitute one gradual series, that he actually calls the classes "degrees of organization." DeBlainville[4] has in the main followed in the steps of Lamarck, though he does not admit quite so simple a series, for he considers the Mollusks and Articulates as two diverging branches ascending from the Radiata, to converge again and unite in the Vertebrata. But since it is now known how the great branches of the animal kingdom may be circumscribed,[5] notwithstanding a few doubtful points; since it is now known how

[1] EHRENBERG, (C. G.,) Das Naturreich des Menschen, oder das Reich der willensfreien beseelten Naturkörper, in 29 Classen übersichtlich geordnet, Berlin, 1835, folio, (1 sheet).

[2] BONNET, (CH.,) Considérations sur les corps organisés, Amsterdam, 1762, 2 vols. 8vo. — Contemplations de la Nature, Amsterdam, 1764–65, 2 vols. 8vo. — Palingénésie philosophique, Genève, 1769, 2 vols. 8vo.

[3] LAMARCK, (J. B. DE,) Philosophie zoologique, Paris, 1809, 2 vols. 8vo.

[4] BLAINVILLE, (H. D. DE,) De l'Organisation des Animaux, Paris, 1822, 1 vol. 8vo.

[5] BLUMENBACH, (J. FR.,) Handbuch der vergleichenden Anatomie, Göttingen, 1824, 1 vol. 8vo.; Engl. by W. LAWRENCE, London, 1827, 1 vol. 8vo. — CUVIER, (G.,) Leçons d'Anatomie comparée, rec. et publ. par MM. Duméril et Duvernoy, Paris, 1800–1805, 5 vols. 8vo.; 2de édit., rev. par MM. F. G. Cuvier et Laurillard, Paris, 1836–39, 10 vols. 8vo. — CUVIER, (G.,) Le Règne animal distribué d'après son organisation, Paris, 1817, 4 vols. 8vo.;

most classes should be characterized, and what is their respective standing; since every day brings dissenting views, respecting the details of classification, nearer together, the supposition that all animals constitute one continuous gradated series, can be shown to be contrary to nature. Yet the greatest difficulty in this inquiry, is to weigh rightly the respective standing of the four great branches of the whole animal kingdom; for, however plain the inferiority of the Radiata may seem, when compared with the bulk of the Mollusks or Articulata, or still more evident when contrasted with the Vertebrata, it must not be forgotten, that the structure of most Echinoderms is far more complicated than that of any Bryozoon or Ascidian of the type of Mollusks, or that of any Helminth, of the type of Articulata, and, perhaps, even superior to that of the Amphioxus among Vertebrata. These facts are so well ascertained, that an absolute superiority or inferiority of one type over the other must be unconditionally denied. As to a relative superiority or inferiority however, determined by the bulk of evidence, though it must be conceded that the Vertebrata rank above the three other types, the question of the relative standing of Mollusks and Articulata seems rather to rest upon a difference in the tendency of their whole organization, than upon a real gradation in their structure; concentration being the prominent trait of the structure of Mollusks, while the expression 'outward display' would more naturally indicate that of Articulata, and so it might seem as if Mollusks and Articulata were standing on nearly a level with one another, and as much

2de édit. 1829–30, 5 vols. 8vo.; 3e édit. illustrée 1836 et suiv; Engl. Trans. by GRIFFITH, London, 1824, 9 vols. 8vo.—MECKEL, (J. F.,) System der vergleichenden Anatomie, Halle, 1821–31, 6 vols. 8vo.; French Transl., Paris, 1829–38, 10 vols. 8vo. —TREVIRANUS, (G. R.,) Biologie, oder Philosophie der lebenden Natur, Göttingen, 1802–16, 6 vols. 8vo. — Die Erscheinungen und Gesetze des organischen Lebens, Bremen, 1831–37, 5 vols. 8vo.—DELLE CHIAJE, Istituzioni d'Anatomia e Fisiologia comparata, Napoli, 1832, 8vo.—CARUS, (C. G.,) Lehrbuch der vergleichenden Anatomie, Leipzic, 1834, 2 vols., 4to., fig. 2d edit.; Grundsätze der vergleichenden Anatomie, Dresden, 1828, 8vo.; Engl. by R. J. GORE, Bath, 1827, 2 vols. 8vo. Atlas.—CARUS, (C. G.,) and OTTO, (A. W.) Erläuterungstafeln zur vergleichenden Anatomie, Leipzic, 1826–40, fol.—WAGNER, (R.,) Lehrbuch der vergleichenden Anatomie, Leipzic, 1834–35, 2 vol. 8vo.; Engl. by A. TULK, London, 1844, 1 vol. 8vo.; 2d edit. Lehrbuch der Zootomie, Leipzic, 1843–44, 1 vol. 8vo., 2d vol. by FREY and LEUCKARDT; Icones anatomicæ, Leipzig, 1841, fol. —GRANT, (R. E.) Outlines of Comparative Anatomy, London, 1835, 1 vol. fol.—JONES, (RYMER,) A General Outline of the Animal Kingdom, London, 1838–39, 1 vol. 8vo. fig.; 2d edit. 1854.—TODD, (R. B.,) Cyclopedia of Anatomy and Physiology, London, 1835–52, 4 vol. 8vo. fig.—AGASSIZ, (L.,) and GOULD, (A. A.,) Principles of Zoölogy, Boston, 1 vol. 8vo., 2d edit. 1851.—OWEN, (R.,) Lectures on the Invertebrate Animals, London, 1843, 1 vol. fig.; 2d edit. 1855.—Lectures on the Comparative Anatomy of the Vertebrate Animals, Fishes, London, 1846, 1 vol. 8vo. fig.—SIEBOLD, (C. TH. v.,) und STANNIUS, (HERM.,) Lehrbuch der vergleichenden Anatomie, Berlin, 1845–46, 2 vol. 8vo.; 2d edit. 1855; Engl. Trans. by W. J. BURNETT, Boston, 1854.—BERGMANN, (C.,) und LEUCKARDT, (R.,) Vergleichende Anatomie und Physiologie, Stuttgardt, 1852, 1 vol. 8vo. fig.

above Radiata, as both stand below Vertebrata, but constructed upon plans expressing different tendencies. To appreciate more precisely these most general relations among the great types of the animal kingdom, will require deeper investigations into the character of their plan of structure than have been made thus far.[1] Let, however, the respective standing of these great divisions be what it may; let them differ only in tendency, or in plan of structure, or in the height to which they rise, admitting their base to be on one level or nearly so, so much is certain, that in each type there are representatives exhibiting a highly complicated structure and others which appear very simple. Now, the very fact that such extremes may be traced, within the natural boundaries of each type, shows that in whatever manner these great types are supposed to follow one another in a single series, the highest representative of the preceding type must join on to the lowest representative of the following, thus bringing necessarily together the most heterogeneous forms.[2] It must be further evident, that in proportion as the internal arrangement of each great type will be more perfected, the greater is likely to appear the difference at the two ends of the series which are ultimately to be brought into connection with those of other series, in any attempt to establish a single series for all animals.

I doubt whether there is a naturalist now living who could object to an arrangement in which, to determine the respective standing of Radiata, Polyps would be placed lowest, Acalephs next, and Echinoderms highest; a similar arrangement of Mollusks would bring Acephala lowest, Gasteropoda next, and Cephalopoda highest; Articulata would appear in the following order: Worms, Crustacea, and Insects, and Vertebrata, with the Fishes lowest, next Reptiles and Birds, and Mammalia highest. I have here purposely avoided every allusion to controverted points. Now if Mollusks were to follow Radiata in a simple series, Acephala should join on to the Echinoderms; if Articulata, Worms would be the connecting link. We should then have either Cephalopods or Insects, as the highest term of a series beginning with Radiata, followed by Mollusks or by Articulates. In the first case, Cephalopods would be followed by Worms; in the second, Insects by Acephala. Again, the connection with Vertebrata would be made either by Cephalopods, if Articulata were considered as lower than Mollusks, or by Insects, if Mollusks were placed below Articulata. Who does not see, therefore, that in proportion as our knowledge of the true affinities of animals is improving, we accumulate more and more convincing evidence against the idea that the animal kingdom constitutes one simple series?

[1] I regret to be unable to refer here to the contents of a course of lectures which I delivered upon this subject, in the Smithsonian Institution, in 1852. Compare, meanwhile, my paper, On the Differences between Progressive, Embryonic, and Prophetic Types, Proc. Am. Assoc. for 1849, p. 432.

[2] AGASSIZ, (L.,) Animal Morphology, Proc. Am. Assoc. for 1849, p. 415.

The next question would then be: Does the animal kingdom constitute several, or any number of graduated series? In attempting to ascertain the value of the less comprehensive groups, when compared to one another, the difficulties seem to be gradually less and less. It is already possible to mark out with tolerable precision, the relative standing between the classes, though even here we do not yet perceive in all the types the same relations. Among Vertebrata, there can be little if any doubt, that the Fishes are lower than the Reptiles, these lower than Birds, and that Mammalia stand highest; it seems equally evident, that in the main, Insects and Crustacea are superior to Worms, Cephalopods to Gasteropods and Acephala and Echinoderms to Acalephs and Polypi. But there are genuine Insects, the superiority of which over many Crustacea, would be difficult to prove; there are Worms which in every respect appear superior to certain Crustacea; the structure of the highest Acephala seems more perfect than that of some Gasteropods, and that of the Halcyonoid Polyps more perfect than that of many Hydroids. Classes do, therefore, not seem to be so limited in the range of their characters, as to justify in every type a complete serial arrangement among them. But when we come to the orders, it can hardly be doubted that the gradation of these natural divisions among themselves in each class, constitutes the very essence of this kind of groups. As a special paragraph is devoted to the consideration of the character of orders in my next chapter, I need not dwell longer upon this point here.[1] It will be sufficient for me to remark now, that the difficulties geologists have met with, in their attempts to compare the rank of the different types of animals and plants with the order of their succession in different geological periods, has chiefly arisen from the circumstance, that they have expected to find a serial gradation, not only among the classes of the same type, where it is only incomplete, but even among the types themselves, between which such a gradation cannot be traced. Had they limited their comparisons to the orders which are really founded upon gradation, the result would have been quite different; but to do this requires more familiarity with Comparative Anatomy, with Embryology and with Zoölogy proper, than can naturally be expected of those, the studies of which are chiefly devoted to the investigation of the structure of our globe.

To appreciate fully the importance of this question of the gradation of animals, and to comprehend the whole extent of the difficulties involved in it, a superficial acquaintance with the perplexing question of the order of succession of animals in past geological ages, is by no means sufficient; a complete familiarity with the many attempts which have been made to establish a correspondence between the two, and with all the eruditics which have been published upon this subject, might dispel

[1] See Chap. II.

every hope to arrive at any satisfactory result upon this subject, did it not appear now, that the inquiry must be circumscribed within different limits, to be conducted upon its true ground. The results to which I have already arrived, since I have perceived the mistake under which investigators have been laboring thus far, in this respect, satisfy me that the point of view under which I have presented the subject here is the true one, and that in the end, the characteristic gradation exhibited by the orders of each class, will present the most striking correspondence with the character of the succession of the same groups in past ages, and afford another startling proof of the admirable order and gradation which have been established from the very beginning, and maintained through all times in the degrees of complication of the structure of animals.

SECTION IX.

RANGE OF GEOGRAPHICAL DISTRIBUTION OF ANIMALS.

The surface of the earth being partly formed by water and partly by land, and the organization of all living beings standing in close relation to the one or the other of these mediums, it is in the nature of things, that no single species, either of animals or plants, should be uniformly distributed over the whole globe. Yet there are some types of the animal, as well as of the vegetable kingdom, which are equably distributed over the whole surface of the land, and others which are as widely scattered in the sea, while others are limited to some continent or some ocean, to some particular province, to some lake, nay, to some very limited spot of the earth's surface.[1]

As far as the primary divisions of animals are concerned, and the nature of the medium to which they are adapted does not interfere, representatives of the four great branches of the animal kingdom are everywhere found together. Radiata, Mollusks, Articulata, and Vertebrata occur together in every part of the ocean, in the Arctics, as well as under the equator, and near the southern pole as far as man has penetrated; every bay, every inlet, every shoal is haunted by them. So univer-

[1] The human race affords an example of the wide distribution of a terrestrial type; the Herring and the Mackerel families have an equally wide distribution in the sea. The Mammalia of New Holland show how some families may be limited to one continent; the family of Labyrinthici of the Indian Ocean, how fishes may be circumscribed in the sea, and that of the Goniodonts of South America in the fresh waters. The Chaca of Lake Baikal is found nowhere else; this is equally true of the Blindfish (Amblyopsis) of the Mammoth Cave, and of the Proteus of the caverns of Carinthia.

sal is this association, not only at present but in all past geological ages, that I consider it as a sufficient reason to expect, that fishes will be found in those few fossiliferous beds of the Silurian System, in which thus far they have not yet been found.[1] Upon land, we find equally everywhere Vertebrata, Articulata, and Mollusks, but no Radiata, this whole branch being limited to the waters; but as far as terrestrial animals extend, we find representatives of the other three branches associated, as we find them all four in the sea. Classes have already a more limited range of distribution. Among Radiata, the Polypi, Acalephs, and Echinoderms[2] are not only all aquatic, they are all marine, with a single exception,[3] the genus Hydra, which inhabits fresh waters. Among Mollusks,[4] the Acephala are all aquatic, but partly marine and partly fluviatile, the Gasteropoda partly marine, partly fluviatile and partly terrestrial, while all Cephalopoda are marine. Among Articulata,[5] the Worms are partly marine, partly fluviatile, and partly terrestrial, while many are internal

[1] See, above, Sect. 7.

[2] For the geographical distribution of Radiata, consult: DANA, (J. D.,) Zoophytes. United States Exploring Expedition, under the command of Ch. Wilkes, U. S. N., Philadelphia, 1846, 1 vol. 4to. Atlas fol. — MILNE-EDWARDS et HAIME, (JUL.,) Recherches sur les Polypiers, Ann. Sc. Nat. 3e sér. vol. 9–18, Paris, 1848–52, 8vo. — ESCHSCHOLTZ, (FR.,) System der Acalephen, Berlin, 1829, 4to. fig. — LESSON, (R. PR.,) Histoire naturelle des Zoophytes, Acalèphes, Paris, 1843, 1 vol. 8vo. fig. — KÖLLIKER, (A.,) Die Schwimmpolypen und Siphonophoren von Messina, Leipzic, 1853, 1 vol. fol. fig. — MÜLLER, (J.,) und TROSCHEL, (F. H.,) System der Asteriden, Braunschweig, 1842, 8vo. fig. — AGASSIZ, (L.,) Catalogue raisonné des familles, des genres et des espèces de la Classe des Echinodermes, Ann. des Sc. Nat. 3e sér. vol. 6–8, Paris, 1847, 8vo.

[3] I need hardly say in this connection that the so-called fresh-water Polyps, Alcyonella, Plumatella, etc., are Bryozoa, and not true Polyps.

[4] For the geographical distribution of Mollusks, consult: LAMARCK, (J. B. DE,) Histoire naturelle des Animaux sans vertèbres, Paris, 1815–22, 7 vols. 8vo.; 2de édit. augmentée de notes par MM. DESHAYES and MILNE-EDWARDS, Paris, 1835–43, 10 vols. 8vo. — FERUSSAC, (J. B. L. DE,) Histoire naturelle des Mollusques terrestres et fluviatiles. Paris, 1819 et suiv, 4to. fig. fol., continuée par DESHAYES. — FERUSSAC, (J. B. L. DE,) et SANDER-RANG, (A.,) Histoire naturelle des Aplysiens, Paris, 1828, 4to. fig. fol. — FERUSSAC, (J. B. L. DE,) et D'ORBIGNY, (A.,) Monographie des Céphalopodes cryptodibranches, Paris, 1834–43, fol. — MARTINI, (F. H. W.,) und CHEMNITZ, (J. H.) Neues systematisches Conchylien-Kabinet, Nürnberg, 1769–95, 11 vols. 4to. fig.; new edit. and continuation by SCHUBERT and A. WAGNER, completed by H. C. KÜSTER, Nürnberg, 11 vols. 4to. fig. — KIENER, (L. C.,) Spécies général et Iconographie des Coquilles vivantes, Paris, 1834, et suiv, 8vo. fig. — REEVE, (Lovell,) Conchologia Iconica; a Complete Repertory of Species of Shells, Pictorial and Descriptive, London, 1843, and foll., 4to. fig. — PFEIFFER, (L.,) Monographia Heliceorum viventium, Leipzig, 1847–48, 8vo. — PFEIFFER, (L.,) Monographia Pneumonopomorum viventium, Cassel, 1852, 8vo., and all the special works on Conchology.

[5] The mode of distribution of free or parasitic Worms, in different parts of the world and in different animals, may be ascertained from: GRUBE, (A. ED.) Die Familien der Anneliden, Wiegman's Archiv, 1850. I mention this paper in preference to any other work, as it is the only complete list of Annulata; and though the localities are not given, the references may supply the deficiency. — RUDOLPHI, (K. A.,) Entozoorum sive Vermium intestinalium Historia naturalis, Amstelodami, 1808–10, 3 vols.

parasites, living in the cavities or in the organs of other animals; the Crustacea are partly marine and partly fluviatile, a few are terrestrial; the Insects are mostly terrestrial or rather aërial, yet some are marine, others fluviatile, and a large number of those, which in their perfect state live in the air, are terrestrial or even aquatic during their earlier stages of growth. Among Vertebrata [1] the Fishes are all aquatic, but partly marine and partly fluviatile; the Reptiles are either aquatic, or amphibious or terrestrial, and some of the latter are aquatic during the early part of their life; the Birds are all aërial, but some more terrestrial and others more aquatic; finally, the Mammalia though all aërial live partly in the sea, partly in fresh water, but mostly upon land. A more special review might show, that this localization in connection with the elements in which animals live, has a direct reference to peculiarities of structure of such importance, that a close consideration of the habitat of animals within the limits of the classes, might in most cases lead to a very natural classification.[2] But this is true only within the limits of the classes, and even here

8vo. fig.—Entozoorum Synopsis, Berolini, 1819, 8vo. fig.—GURLT, (E. F.,) Verzeichniss der Thiere, bei welchen Entozoen gefunden worden sind, Wiegman's Archiv, 1845, contin. by Creplin in the following No.—DUJARDIN, (FEL.,) Histoire naturelle des Helminthes ou Vers intestinaux, Paris, 1844, 1 vol. 8vo.—DIESING, (C. M.,) Historia Vermium, Vindob. 1850, 2 vols. 8vo. That of Crustacea from MILNE-EDWARDS, Histoire naturelle des Crustacés, Paris, 1834, 3 vols. 8vo. fig.—DANA, (J. D.,) Crustacea. United States Exploring Expedition, under the command of Ch. Wilkes, U. S. N., vol. xiv., Philadelphia, 1852, 2 vols. 4to., atlas, fol. For the geographical distribution of Insects I must refer to the general works on Entomology, as it would require pages to enumerate even the standard works relating to the different orders of this class; but they are mentioned in: PERCHERON, (ACH. R.,) Bibliographie entomologique, Paris, 1837, 2 vols. 8vo.—AGASSIZ, (L.,) Bibliographia Zoologiæ et Geologiæ; a general catalogue of all books, tracts, and memoirs on Zoölogy and Geology, corrected, enlarged, and edited by H. E. STRICKLAND, London, 1848–54, 4 vols. 8vo. (Ray Society).

[1] For the geographical distribution of Fishes, consult: CUVIER, (G.,) and VALENCIENNES, (A.,) Histoire naturelle des Poissons, Paris, 1828–1849, 22 vols. 8vo., fig.—MÜLLER, (J.,) und HENLE, (J.,) Systematische Beschreibung der Plagiostomen, Berlin, 1841, fol. fig. For that of Reptiles: DUMERIL, (A. M. C.,) et BIBRON, (G.,) Erpétologie générale, ou Histoire naturelle complète des Reptiles, Paris, 1834–1855, 9 vols. 8vo. fig.—TSCHUDI, (J. J.,) Classification der Batrachier, Neuchâtel, 1838, 4to. Mém. Soc. Neuch. 2d. vol.—FITZINGER, (L. J.,) Systema Reptilium, Vindobonæ, 1843, 8vo. For that of Birds: GRAY, (G. R.,) The Genera of Birds, illustrated with about 350 plates by D. W. Mitchell, London, 1844–1849, 3 vols. imp. 4to.—BONAPARTE, (C. L.,) Conspectus generum Avium, Lugduni-Batavorum, 1850, and seq. 8vo. For that of Mammalia: WAGNER, (A.,) Die geographische Verbreitung der Säugthiere, Verhandl. der Akad. der Wissensch. in München, Vol. IV.—POMPPER, (Herm.,) Die Säugthiere, Vögel und Amphibien, nach ihrer geographischen Verbreitung tabellarish zusammengestellt, Leipzig, 1841, 4to.—See, also, the annual reports in Wiegman's Archiv, now edited by Troschell; the Catalogues of the British Museum, of the Jardin des Plantes, etc.

[2] AGASSIZ, (L.,) The Natural Relations between Animals and the Elements in which they live. Amer. Jour. of Sc. and Arts, 2d ser., vol. 9, 1850, 8vo., p. 369.

not absolutely, as in some the orders only, or the families only are thus closely related to the elements; there are even natural groups, in which this connection is not manifested beyond the limits of the genera, and a few cases in which it is actually confined to the species. Yet, in every degree of these connections, we find that upon every spot of the globe, it extends simultaneously to the representatives of different classes and even of different branches of the animal and vegetable kingdoms; a circumstance which shows that when called into existence, in such an association, these various animals and plants were respectively adapted with all the peculiarities of their kingdom, those of their class, those of their order, those of their genus, and those of their species, to the home assigned to them, and therefore, not produced by the nature of the place, or of the element, or any other physical condition. To maintain the contrary, would really amount to asserting that wherever a variety of organized beings live together, no matter how great their diversity, the physical agents prevailing there, must have in their combined action, the power of producing such a diversity of structures as exists in animals, notwithstanding the close connection in which these animals stand to them, or to work out an intimate relation to themselves in beings, the essential characteristics of which, have no reference to their nature. In other words, in all these animals and plants, there is one side of their organization which has an immediate reference to the elements in which they live, and another which has no such connection, and yet it is precisely this part of the structure of animals and plants, which has no direct bearing upon the conditions in which they are placed in nature, which constitutes their essential, their typical character. This proves beyond the possibility of an objection, that the elements in which animals and plants live (and under this expression I mean to include all that is commonly called physical agents, physical causes, etc.,) cannot in any way be considered as the cause of their existence.

If the naturalists of past centuries have failed to improve their systems of Zoölogy by introducing considerations derived from the habitat of animals, it is chiefly because they have taken this habitat as the foundation of their primary divisions; but reduced to its proper limits, the study of the connection between the structure and the natural home of animals cannot fail to lead to interesting results, among which, the growing conviction that these relations are not produced by physical agents, but determined in the plan ordained from the beginning, will not be the least important.

The unequal limitation of groups of a different value, upon the surface of the earth, produces the most diversified combinations possible, when we consider the mode of association of different families of animals and plants in different parts of the world. These combinations are so regulated that every natural province has a character of its own, as far as its animals and plants are concerned, and such natural associations of organized beings extending over a wider or narrower area are called *Faunæ* when the animals alone are considered, and *Floræ* when the plants alone are regarded. Their natural limits are far from being yet ascertained satisfactorily everywhere. As the works of Schow and Schmarda may suffice to give an approximate idea of their extent,[1] I would refer to them for further details, and allude here only to the unequal extent of these different faunæ, and to the necessity of limiting them in different ways, according to the point of view under which they are considered, or rather show that, as different groups have a wider or more limited range, in investigating their associations, or the faunæ, we must distinguish between zoölogical realms, zoölogical provinces, zoölogical counties, zoölogical fields, as it were; that is, between zoölogical areas of unequal value over the widest of which range the most extensive types, while in their smaller and smaller divisions, we find more and more limited types, sometimes overlapping one another, sometimes placed side by side, sometimes concentric to one another, but always and everywhere impressing a special character upon some part of a wider area, which is thus made to differ from that of any other part within its natural limits.

These various combinations of smaller or wider areas, equally well defined in different types, has given rise to the conflicting views prevailing among naturalists respecting the natural limits of faunæ; but with the progress of our knowledge these discrepancies cannot fail to disappear. In some respect, every island of the Pacific upon which distinct animals are found, may be considered as exhibiting a distinct fauna, yet several groups of these islands have a common character, which unites them into more comprehensive faunæ, the Sandwich Islands for instance, compared to the Fejees or to New Zealand. What is true of disconnected islands or of isolated lakes is equally true of connected parts of the mainland and of the ocean.

Since it is well known that many animals are limited to a very narrow range in their geographical distribution, it would be a highly interesting subject of inquiry to ascertain what are the narrowest limits within which animals of different types may be circumscribed, as this would furnish the first basis for a scientific consideration of the conditions under which animals may have been created. The time is passed when the mere indication of the continent whence an animal had been obtained, could satisfy our curiosity; and the naturalists who, having an opportunity of ascertaining closely the particular circumstances under which the animals they describe are placed in their natural home, are guilty of a gross disregard of the interest of science when they neglect to relate them. Our knowledge of the geographical distribution of animals would be far more extensive and precise than it

[1] I would also refer to a sketch I have published of the Faunæ in NOTT's and GLIDDON's Types of Mankind, Philadelphia, 1854, 4to., accompanied with a map and illustrations.

is now, but for this neglect; every new fact relating to the geographical distribution of well-known species is as important to science as the discovery of a new species. Could we only know the range of a single animal as accurately as Alphonse DeCandolle has lately determined that of many species of plants, we might begin a new era in Zoölogy. It is greatly to be regretted that in most works, containing the scientific results of explorations of distant countries, only new species are described, when the mere enumeration of those already known might have added invaluable information respecting their geographical distribution. The carelessness with which some naturalists distinguish species merely because they are found in distant regions, without even attempting to secure specimens for comparison, is a perpetual source of erroneous conclusions in the study of the geographical distribution of organized beings, not less detrimental to the progress of science than the readiness of others to consider as identical, animals and plants which may resemble each other closely, without paying the least regard to their distinct origin, and without even pointing out the differences they may perceive between specimens from different parts of the world. The perfect identity of animals and plants living in very remote parts of the globe has so often been ascertained, and it is also so well known how closely species may be allied and yet differ in all the essential relations which characterize species, that such loose investigations are no longer justifiable.

This close resemblance of animals and plants in distant parts of the world is the most interesting subject of investigation with reference to the question of the unity of origin of animals, and to that of the influence of physical agents upon organized beings in general. It appears to me that as the facts point now distinctly to an independent origin of individuals of the same species in remote regions, or of closely allied species representing one another in distant parts of the world, one of the strongest arguments in favor of the supposition that physical agents may have had a controlling influence in changing the character of the organic world, is gone for ever.

The narrowest limits within which certain Vertebrata may be circumscribed, is exemplified, among Mammalia, by some large and remarkable species: the Orang-Outangs upon the Sunda Islands, the Chimpanzee and the Gorilla along the western coast of Africa, several distinct species of Rhinoceros about the Cape of Good Hope, and in Java and Sumatra, the Pinchaque and the common Tapir in South America, and the eastern Tapir in Sumatra, the East Indian and the African Elephant, the Bactrian Camel and the Dromedary, the Llamas, and the different kinds of wild Bulls, wild Goats, and wild Sheep, etc.; among birds by the African Ostrich, the two American Rheas, the Casovary (Dromicejus) of New Holland, and the Emeu (Casuarius galeatus) of the Indian Archipelago, and still more by the different species of doves confined to particular islands in the Pacific Ocean; among Reptiles, by the Proteus of the cave of Adelsberg in Carinthia, by the Gopher (Testudo Polyphemus Auct.) of our Southern States; among fishes, by the Blind Fish (Amblyopsis spelæus) of the Mammoth Cave. Examples of closely limited Articulata may not be so striking, yet the Blind Crawfish of the Mammoth Cave and the many parasites found only upon or within certain species of animals, are very remarkable in this respect. Among Mollusks, I would remark the many species of land shells, ascertained by Professor Adams to occur only in Jamaica,[1] among the West India Islands, and the species discovered by the United States Exploring Expedition upon isolated islands of the Pacific, and described by Dr. Gould.[2] Even among Radiata many species might be quoted, among Echinoderms as well as among Medusæ and Polypi, which are only known from a few localities; but as long as these animals are not collected with the special view of ascertaining their geographical range, the indications of travellers must be received with great caution, and any generalization respecting the extent of their natural area would be premature as long as the countries they inhabit have not been more extensively explored. It is nevertheless true as established by ample evidence, that within definite limits all the animals occurring in different natural zoölogical provinces are specifically distinct. What remains to be ascertained more minutely is the precise range of each species, as well as the most natural limits of the different faunæ.

SECTION X.

IDENTITY OF STRUCTURE OF WIDELY DISTRIBUTED TYPES.

It is not only when considering the diversification of the animal kingdom within limited geographical areas, that we are called upon in our investigations to admire the unity of plan its most diversified types may exhibit; the identity of structure of these types is far more surprising, when we trace it over a wide range of country, and within entirely disconnected areas. Why the animals and plants of North America should present such a strong resemblance to those of Europe and Northern Asia, while those of Australia are so entirely different from those of Africa and South America under the same latitudes, is certainly a problem of great interest in connec-

[1] ADAMS, (C. B.,) Contributions to Conchology, New York, 1849–50, 8vo. A series of pamphlets, full of original information.

[2] GOULD, (A. A.,) Mollusks, United States Exploring Expedition, under the command of CH. WILKES, U. S. N., 1 vol. 4to. Philadelphia, 1854.

tion with the study of the influence of physical agents upon the character of animals and plants in different parts of the world. North America certainly does not resemble Europe and Northern Asia, more than parts of Australia resemble certain parts of Africa or of South America, and even if a greater difference should be conceded between the latter than between the former, these disparities are in no way commensurate with the difference or similarity of their organized beings, nor in any way rationally dependent one upon the other. Why should the identity of species prevailing in the Arctics not extend to the temperate zone, when many species of this zone, though different, are as difficult to distinguish, as it is difficult to prove the identity of certain arctic species, in the different continents converging to the north, and when besides, those of the two zones mingle to a great extent at their boundaries? Why are the antarctic species not identical with those of the arctic regions? And why should a further increase of the average temperature introduce such completely new types, when even in the Arctics, there are in different continents such strikingly peculiar types (the Rhytina for instance,) combined with those that are *identical over the whole arctic area?*[1]

It may at first sight seem very natural that the arctic species should extend over the three northern continents converging towards the north pole, as there can be no insuperable barrier to the widest dissemination over this whole area for animals living in a glacial ocean or upon parts of three continents which are almost bound together by ice. Yet the more we trace this identity in detail, the more surprising does it appear, as we find in the Arctics as well as everywhere else, representatives of different types living together. The arctic Mammalia belonging chiefly to the families of Whales, Seals, Bears, Weasels, Foxes, Ruminants and Rodents, have, as Mammalia, the same general structure as the Mammalia of any other part of the globe, and so have the arctic Birds, the arctic Fishes, the arctic Articulata, the arctic Mollusks, the arctic Radiata when compared to the representatives of the same types all over our globe. This identity extends to every degree of affinity among these animals and the plants which accompany them; their orders, their families, and their genera as far as they have representatives elsewhere, bear everywhere the same identical ordinal, family, or generic characters; the arctic foxes have the same

[1] I beg not to be misunderstood. I do not impute to all naturalists the idea of ascribing all the differences or all the similarities of the organic world to climatic influences; I wish only to remind them that even the truest picture of the correlations of climate and geographical distribution, does not yet touch the question of origin, which is the point under consideration. Too little attention has thus far been paid to the facts bearing upon the peculiarities of structure of animals in connection with the range of their distribution. Such investigations are only beginning to be made, as native investigators are studying comparatively the anatomy of animals of different continents.

dental formula, the same toes and claws, in fact, every generic peculiarity which characterizes foxes, whether they live in the Arctics, or in the temperate or tropical zone, in America, in Europe, in Africa, or in Asia. This is equally true of the seals or the whales; the same details of structure which characterize their genera in the Arctics reappear in the Antarctics, and the intervening space, as far as their natural distribution goes. This is equally true of the birds, the fishes, etc., etc. And let it not be supposed that it is only a general resemblance. By no means. The structural identity extends to the most minute details in the most intimate structure of the teeth, of the hair, of the scales, in the furrows of the brain, in the ramification of the vessels, in the folds of the internal surface of the intestine, in the complication of the glands, etc., etc., to peculiarities, indeed, which nobody but a professional naturalist, conversant with microscopic anatomy, would ever believe could present such precise and permanent characters. So complete, indeed, is this identity, that were any of these beings submitted to the investigation of a skilful anatomist, after having been mutilated to such an extent that none of its specific characters could be recognized, yet not only its class, or its order, or its family, but even its genus, could be identified as precisely as if it were perfectly well preserved in all its parts. Were the genera few which have a wide range upon the earth and in the ocean, this might be considered as an extraordinary case; but there is no class of animals and plants which does not contain many genera, more or less cosmopolite in their geographical distribution. The number of animals which have a wide distribution is even so great that, as far at least as genera are concerned, it may fairly be said, that the majority of them have an extensive geographical range. This amounts to the most complete evidence that, as far as any of these genera extends in its geographical distribution, animals the structure of which is identical within this range of distribution, are entirely beyond the influence of physical agents, unless these agents have the power, notwithstanding their extreme diversity, within these very same geographical limits, to produce absolutely identical structures of the most diversified types.

It must be remembered here, that there are genera of Vertebrata, of Articulata, of Mollusks, and of Radiata, which occupy the same identical and wide geographical distribution, and that while the structure of their respective representatives is identical over the whole area, as Vertebrata, as Articulata, as Mollusks, as Radiata, they are at the same time built upon the most different plans. I hold this fact to be in itself a complete demonstration of the entire independence of physical agents of the structure of animals, and I may add that the vegetable kingdom presents a series of facts identical with these. This proves that all the higher relations among animals and plants are determined by other causes than mere physical influences.

While all the representatives of the same genus are identical in structure,[1] the different species of one genus differ only in their size, in the proportions of their parts, in their ornamentation, in their relations to the surrounding elements, etc. The geographical range of these species varies so greatly, that it cannot afford in itself a criterion for the distinction of species. It appears further, that while some species which are scattered over very extensive areas, occupy disconnected parts of that area, other species closely allied to one another and which are generally designated under the name of representative species, occupy respectively such disconnected sections of these areas. The question then arises, how these natural boundaries assigned to every species are established. It is now generally believed that each species had, in the beginning, some starting point, from which it has spread over the whole range of the area it now occupies, and that this starting point is still indicated by the prevalence or concentration of such species in some particular part of its natural area, which, on that account, is called its centre of distribution or centre of creation, while at its external limits the representatives of such species thin out, as it were, occurring more sparsely and sometimes in a reduced condition.

It was a great progress in our science, when the more extensive and precise knowledge of the geographical distribution of organized beings forced upon its cultivators the conviction, that neither animals nor plants could have originated upon one and the same spot upon the surface of the earth, and hence have spread more and more widely until the whole globe became inhabited. It was really an immense progress which freed science from the fetters of an old prejudice; for now we have the facts of the case before us, it is really difficult to conceive how, by assuming such a gradual dissemination from one spot, the diversity which exists in every part of the globe could ever have seemed to be explained. But even to grant distinct centres of distribution for each species within their natural boundaries, is only to meet the facts half way, as there are innumerable relations between the animals and plants which we find associated everywhere, which must be considered as primitive, and cannot be the result of successive adaptation. And if this be so, it would follow that all animals and plants have occupied, from the beginning, those natural boundaries within which they stand to one another in such harmonious relations.[2] Pines have originated in forests, heaths in heathers, grasses in prairies, bees in hives, herrings in schools, buffaloes in herds, men in nations![3] I see a striking proof that this must have been the case in the circumstance, that representative species, which,

[1] See hereafter, Chap. II. Sect. 5.

[2] Agassiz, (L.) Geographical Distribution of Animals, Christian Examiner, Boston, 1850, 8vo. (March).

[3] Agassiz, (L.) The Diversity of Origin of the Human Races, Christian Examiner, Boston, 1850, 8vo. (February).

as distinct species, must have had from the beginning a different and distinct geographical range, frequently occupy sections of areas which are simultaneously inhabited by the representatives of other species, which are perfectly identical over the whole area. By way of an example, I would mention the European and the American Widgeon, (*Anas 'Mareca' Penelope* and *A. americana*,) or the American and the European Red-headed Ducks, (*A. ferina* and *A. erythrocephala*,) which inhabit respectively the northern parts of the Old and New World in summer, and migrate further south in these same continents during winter, while the Mallard (*A. Boschas*) and the Scaup Duck (*A. marila*) are as common in North America as in Europe. What do these facts tell: That all these birds originated together somewhere, where they no longer occur, to establish themselves in the end within the limits they now occupy?—or that they originated either in Europe or America, where, it is true, they do not live all together, but at least a part of them?—or that they really originated within the natural boundaries they occupy? I suppose with sensible readers I need only argue the conclusions flowing from the last supposition. If so, the American Widgeon and the American Red-headed Duck originated in America, and the European Widgeon and the European Red-headed Duck in Europe. But what of the Mallard and the Scaup, which are equally common upon the two continents; did they first appear in Europe, or in America, or simultaneously upon the two continents? Without entering into further details, as I have only desired to lay clearly a distinct case before my readers, from which the character of the argument, which applies to the whole animal kingdom, may be fully understood, I say that the facts lead, step by step, to the inference, that such birds as the Mallard and the Scaup originated simultaneously and separately in Europe and in America, and that all animals originated in vast numbers, indeed, in the average number characteristic of their species, over the whole of their geographical area, whether its surface be continuous or disconnected by sea, lakes, or rivers, or by differences of level above the sea, etc. The details of the geographical distribution of animals exhibit, indeed, too much discrimination to admit for a moment that it could be the result of accident, that is, the result of the accidental migrations of the animals or of the accidental dispersion of the seeds of plants. The greater the uniformity of structure of these widely distributed organized beings, the less probable does their accidental distribution appear. I confess that nothing has ever surprised me so much as to see the perfect identity of the most delicate microscopic structures of animals and plants, from the remotest parts of the world. It was this striking identity of structure in the same types, this total independence of the essential characteristics of animals and plants, of their distribution under the most extreme climatic differences known upon our globe, which led me to distrust the belief, then almost universal, that organized beings are influenced by physical causes to a degree which may essentially modify their character.

SECTION XI.

COMMUNITY OF STRUCTURE AMONG ANIMALS LIVING IN THE SAME REGIONS.

The most interesting result of the earliest investigations of the fauna of Australia was the discovery of a type of animals, the Marsupialia, prevailing upon this continental island, which are unknown in almost every other part of the world. Every student of Natural History knows now that there are no *Quadrumana* in New Holland, neither Monkeys, nor Makis: no *Insectivora*, neither Shrews, nor Moles, nor Hedgehogs; no true *Carnivora*,[1] neither Bears, nor Weasels, nor Foxes, nor Viverras, nor Hyenas, nor Wild Cats; no *Edentata*, neither Sloths, nor Tatous, nor Ant-eaters, nor Pangolins; no *Pachyderms*, neither Elephants, nor Hippopotamuses, nor Hogs, nor Rhinoceroses, nor Tapirs, nor Wild Horses; no *Ruminantia*, neither Camels, nor Llamas, nor Deers, nor Goats, nor Sheep, nor Bulls, etc., and yet the Mammalia of Australia are almost as diversified as those of any other continent. In the words of Waterhouse,[2] who has studied them with particular care, "the Marsupialia present a remarkable diversity of structure, containing herbivorous, carnivorous, and insectiverous species; indeed, we find amongst the marsupial animals analogous representations of most of the other orders of Mammalia. The *Quadrumana* are represented by the Phelangers, the *Carnivora* by the Dasyuri, the *Insectivora* by the small Phascogales, the *Ruminantia* by the Kangaroos, and the *Edentata* by the Monotremes. The Cheiroptera are not represented by any known marsupial animals, and the Rodents are represented by a single species only; the hiatus is filled up, however, in both cases, by placental species, for Bats and Rodents are tolerably numerous in Australia, and, if we except the Dog, which it is probable has been introduced by man, these are the only placental Mammalia found in that continent." Nevertheless, all these animals have in common some most striking anatomical characters, which distinguish them from all other Mammalia, and stamp them as one of the most natural groups of that class; their mode of reproduction, and the connection of the young with the mother, are different; so, also, is the structure of their brain, etc.[3]

Now, the suggestion that such peculiarities could be produced by physical agents is for ever set aside by the fact that neither the birds nor the reptiles, nor, indeed, any other animals of New Holland, depart in such a manner from the ordinary char-

[1] Doubts are entertained respecting the origin of the Dingo, the only beast of prey of New Holland.

[2] WATERHOUSE, (G. A.,) Natural History of the Mammalia, London, 1848, 2 vols. 8vo., vol. i., p. 4.

[3] See OWEN, (R.,) Marsupialia in Todd's Cyclopedia of Anat. and Physiol., London, 1841, 8vo., and several elaborate papers by himself and others, quoted there.

acter of their representatives in other parts of the world; unless it could be shown that such agents have the power of discrimination, and may produce, under the same conditions, beings which agree and others which do not agree with those of different continents; not to speak again of the simultaneous occurrence in that same continent of other heterogeneous types of Mammalia, Bats and Rodents, which occur there as well as everywhere else in other continents. Nor is New Holland the only part of the world which nourishes animals highly diversified among themselves, and yet presenting common characters strikingly different from those of the other members of their type, circumscribed within definite geographical areas. Almost every part of the globe exhibits some such group either of animals or of plants, and every class of organized beings contains some native natural group, more or less extensive, more or less prominent, which is circumscribed within peculiar geographical limits. Among Mammalia we might quote further the Quadrumana, the representatives of which, though greatly diversified in the Old as well as in the New World, differ and agree respectively in many important points of their structure; also the Edentata of South America.

Among birds, the Humming Birds, which constitute a very natural, beautiful, and numerous family, all of which are nevertheless confined to America only, as the Pheasants are to the Old World.[1] Among Reptiles, the Crocodiles of the Old World compared to those of America. Among fishes, the family of Labyrinthici, which is confined to the Indian and Pacific Oceans, that of Goniodonts, which is limited to the fresh waters of South America, as that of Cestraciontes to the Pacific. The comparative anatomy of Insects is not sufficiently far advanced to furnish striking examples of this kind; among Insects, however, remarkable for their form, which are limited to particular regions, may be quoted the genus Mormolyce of Java, the Pneumora of the Cape of Good Hope, the Belostoma of North America, the Fulgora of China, etc. The geographical distribution of Crustacea has been treated in such a masterly manner by Dana, in his great work upon the Crustacea of the United States Exploring Expedition, Vol. XIII., p. 1451, that I can only refer to it for numerous examples of localized types of this class, and also as a model how to deal with such subjects. Among Worms, the Peripates of Guiana deserves to be mentioned. Among Cephalopods, the Nautilus in Amboyna. Among Gasteropods, the genus Io in the western waters of the United States. Among Acephala, the Trigonia in New Holland, certain Naiades in the United States, the Aetheria in the Nile. Among Echinoderms, the Pentacrinus in the West Indies, the Culcita in Zanzibar, the Amblypneustes in the Pacific, the Temnopleurus in the Indian Ocean, the Dendraster on the western coast

[1] What are called Pheasants in America do not even belong to the same family as the eastern Pheasants. The American, so-called, Pheasants are genuine Grouses.

of North America. Among Acalephs, the Berenice of New Holland. Among Polypi, the true Fungidæ in the Indian and Pacific Oceans, the Renilla in the Atlantic, etc.

Many more examples might be quoted, were our knowledge of the geographical distribution of the lower animals more precise. But these will suffice to show that whether high or low, aquatic or terrestrial, there are types of animals remarkable for their peculiar structure which are circumscribed within definite limits, and this localization of special structures is a striking confirmation of the view expressed already in another connection, that the organization of animals, whatever it is, may be adapted to various and identical conditions of existence, and can in no way be considered as originating from these conditions.

SECTION XII.

SERIAL CONNECTION IN THE STRUCTURE OF ANIMALS WIDELY SCATTERED UPON THE SURFACE OF OUR GLOBE.

Ever since I have become acquainted with the reptiles inhabiting different parts of the world, I have been struck with a remarkable fact, not yet noticed by naturalists, as far as I know, and of which no other class exhibits such striking examples. This fact is that among Saurians, as well as among Batrachians, there are families, the representatives of which, though scattered all over the globe, form the most natural connected series, in which every link represents one particular degree of development. The Scincoids,[1] among Saurians, are one of these families. It contains about one hundred species, referred by Duméril and Bibron to thirty-one genera, which, in the development of their organs of locomotion, exhibit most remarkable combinations, illustrated in a diagram, on the following page.

Fully to appreciate the meaning of this diagram, it ought to be remembered, that the animals belonging to this family are considered here in two different points of view. In the first place, their zoölogical relations to one another are expressed by the various combinations of the structure of their legs; some having four legs, and these are the most numerous, others only two legs, which are always the hind legs, and others still no legs at all. Again these legs may have only one toe, or two, three, four, or five toes, and the number of toes may vary between the fore and hind legs. The classification adopted here is based upon these characters. In

[1] For the characters of the family, see DUMERIL et BIBRON, Erpétologie générale, vol. 5, p. 511. See also COCTEAU, Etudes sur les Scincoides, Paris, 1836, 4to. fig.

the second place, the geographical distribution is noticed. But it is at once apparent that the home of these animals stands in no relation whatsoever to their zoölogical arrangement. On the contrary, the most remote genera may occur in the same country, while the most closely related may live far apart.

GENERA WITH FOUR LEGS.

With *five* toes to the fore feet, as well as to the hind feet:
- *Tropidophorus*, 1 species, Cochin-China.
- *Scincus*, 1 sp., Syria, North and West Africa.
- *Sphenops*, 1 sp., Egypt.
- *Diploglossus*, 6 sp., West Indies and Brazils.
- *Amphiglossus*, 1 sp., Madagascar.
- *Gongylus*, with 7 sub-genera:
  - *Gongylus*, 2 sp., Southern Europe, Egypt, Teneriffe, Isle de France.
  - *Eumeces*, 11 sp., East and West Indies, South America, Vanikoro, New Ireland, New Guinea, Pacific Islands.
  - *Euprepes*, 13 sp., West coast of Africa, Cape of Good Hope, Egypt, Abyssinia, Seychelles, Madagascar, New Guinea, East Indies, Sunda Islands, Manilla.
  - *Plestiodon*, 5 sp., Egypt, Algiers, China, Japan, United States.
  - *Lygosoma*, 19 sp., New Holland, New Zealand, Java, New Guinea, Timor, East Indies, Pacific Islands, United States.
  - *Leiolopisma*, 1 sp., Mauritius and Manilla.
  - *Tropidolopisma*, 1 sp., New Holland.
- *Cyclodus*, 3 sp., New Holland and Java.
- *Trachysaurus*, 1 sp., New Holland.
- *Ablepharus*, 4 sp., Southeastern Europe, New Holland, Pacific Islands.

With *five* toes to the fore feet and *four* toes to the hind feet: *Campsodactylus*, 1 sp., Bengal.

With *four* toes to the fore feet and *five* toes to the hind feet:
- *Heteropus*, 3 sp., Africa, New Holland, Isle de France.
- *Gymnophthalmus*, 1 sp., W. Indies and Brazil.

With *four* toes to the fore feet and *four* toes to the hind feet:
- *Tetradactylus*, 1 sp., New Holland. The genus Chalcides of the allied family Chalcidioids, exhibits another example of this combination.

With *four* toes to the fore feet and *three* toes to the hind feet: No examples known of this combination.

With *three* toes to the fore feet and *four* toes to the hind feet: Not known.

With *three* toes to the fore feet and *three* toes to the hind feet:
- *Hemiergis*, 1 sp., New Holland.
- *Seps*, 1 sp., S. Europe and N. Africa.
- *Nessia*, 1 sp., Origin unknown.

With *three* toes to the fore feet and *two* toes to the hind feet: Not known.

With *two* toes to the fore feet and *three* toes to the hind feet:
- *Heteromeles*, 1 sp., Algiers.
- *Lerista*, 1 sp., New Holland.

With *two* toes to the fore feet and *two* toes to the hind feet: *Chelomeles*, 1 sp., New Holland.

With *two* toes to the fore feet and *one* toe to the hind feet: *Brachymeles*, 1 sp., Philippine Islands.

With *one* toe to the fore feet and *two* toes to the hind feet: *Brachystopus*, 1 sp., South Africa.

With *one* toe to the fore feet and *one* toe to the hind feet: *Evesia*, 1 sp., Origin unknown.

GENERA WITH ONLY TWO LEGS.

No representatives are known *with fore legs only;* but this structural combination occurs in the allied family of the Chalcidioids. The representatives *with hind legs only,* present the following combinations:—

With *two* toes: *Scelotes,* 1 sp., Cape Good Hope.
With *one* toe: *Propeditus,* 1 sp., Cape Good Hope and New Holland.
Ophiodes, 1 sp., South America.
Hysteropus, 1 sp., New Holland.
Liulis, 1 sp., New Holland.
Dibamus, 1 sp., New Guinea.

GENERA WITHOUT ANY LEGS.

Anguis, 1 sp., Europe, Western Asia, Northern Africa.
Ophiomorus, 1 sp., Morea, Southern Russia, and Algiers.
Acontias, 1 sp., Southern Africa, Cape Good Hope.
Typhlina, 1 sp., Southern Africa, Cape Good Hope.

Who can look at this diagram, and not recognize in its arrangement the combinations of thought? This is so obvious, that while considering it one might almost overlook the fact, that while it was drawn up to classify animals preserved in the Museum of the Jardin des Plantes in Paris, it is in reality inscribed in Nature by these animals themselves, and is only read off when they are brought together, and compared side by side. But it contains an important element for our discussion: the series is not built up of equivalent representatives in its different terms, some combinations being richly endowed, others numbering a few, or even a single genus, and still others being altogether disregarded; such freedom indicates selection, and not the working of the law of necessity.

And if from a contemplation of this remarkable series we turn our attention to the indications relating to the geographical distribution of these so closely linked genera, inscribed after their names, we perceive at once, that they are scattered all over the globe, but not so that there could be any connection between the combinations of their structural characters and their homes. The types without legs are found in Europe, in Western Asia, in Northern Africa, and at the Cape of Good Hope; the types with hind legs only, and with one single toe, at the Cape of Good Hope, in South America, New Holland, and New Guinea; those with two toes at the Cape of Good Hope only. Among the types with four legs the origin of those with but one toe to each foot is unknown, those with one toe in the fore foot and two in the hind foot are from South Africa, those with two toes in the fore foot and one in the hind foot occur in the Philippine Islands, those with two toes to all four feet in New Holland, those with three toes to the hind feet and two to the fore feet in Algiers and New Holland; none are known with three toes to the fore feet and two to the hind feet. Those with three toes to the four feet inhabit Europe, Northern Africa, and New Holland. There are none with three and four toes, either in the fore feet or in the hind feet. Those with four toes to the four feet live in New Holland; those with five toes to the fore feet and four to the hind feet, in Bengal, and with four toes in the fore feet and five in the hind feet, in Africa, the West Indies, the Brazils, and New Holland. Those with five toes to all four feet have the widest distribution, and yet they are so scattered that no single zoölogical province presents any thing like a complete series; on the contrary, the mixture of some of the representatives with perfect feet with others which have them rudimentary, in almost every fauna, excludes still more decidedly the idea of an influence of physical agents upon this development.

Another similar series, not less striking, may be traced among the Batrachians, for the characters of which I may refer to the works of Holbrook, Tschudi, and Baird,[1] even though they have not presented them in this connection, as the characteristics of the genera will of themselves suggest their order, and further details upon this subject would be superfluous for my purpose, the more so, as I have already discussed the gradation of these animals elsewhere.[2]

Similar series, though less conspicuous and more limited, may be traced in every class of the animal kingdom, not only among the living types, but also among the representatives of past geological ages, which adds to the interest of such series in showing, that the combinations include not only the element of space, indicating omnipresence, but also that of time, which involves prescience. The series of Crinoids, that of Brachiopods through all geological ages, that of the Nautiloids, that of Ammonitoids from the Trias to the Cretaceous formation inclusive, that of Trilobites from the lowest beds up to the Carboniferous period, that of Ganoids through all formations; then again among living animals in the class of Mammalia, the series of Monkeys in the Old World especially, that of Carnivora from the Seals, through the Plantigrades, to the Digitigrades; in the class of Birds, that of the Wading Birds, and that of the Gallinaceous Birds; in the class of Fishes, that of Pleuronectidæ and Gadoids, that of Skates and Sharks; in the class of Insects, that of Lepidoptera from the Tineina to the Papilionina; in the class of Crustacea, that of the Decapods in particular; in the class of Worms, that of the Nudibranchiata or that of the Dorsibran-

[1] HOLBROOK, (J. E.,) North American Herpetology, Philadelphia, 1842, 4to.; 5th vol. — TSCHUDI, (J. J.) Classification der Batrachier, Neuchâtel, 1838, 4to. — BAIRD, (SP. F.) Revision of the North American Tailed Batrachia, Journal Acad. Nat. Science, of Philadelphia, 2d series, vol. I., 1849, 4to.

[2] AGASSIZ, (L.,) Twelve Lectures on Comparative Embryology, Boston, 1849, 8vo.; p. 8.

chiata especially; in the class of Cephalopoda, that of the Sepioids; in the class of Gasteropoda, that of the Nudibranchiata in particular; in the class of Acephala, that of the Ascidians and that of the Oysters in the widest sense; in the class of Echinoderms, those of Holothuriæ and Asterioids; in the class of Acalephs, that of the Hydroids; in the class of Polyps, that of the Halcyonoids, of the Atræoids, etc., etc., deserve particular attention, and may be studied with great advantage in reference to the points under consideration. For everywhere do we observe in them, with reference to space and to time, the thoughtful combinations of an active mind. But it ought not to be overlooked, that while some types represent strikingly connected series, there are others in which nothing of the kind seems to exist, and the diversity of which involves other considerations.

SECTION XIII.

RELATION BETWEEN THE SIZE OF ANIMALS, AND THEIR STRUCTURE.

The relation between the size and structure of animals has been very little investigated, though even the most superficial survey of the animal kingdom may satisfy any one, that there is a decided relation between size and structure among them. Not that I mean to assert that size and structure form parallel series, or that all animals of one branch, or even those of the same class or the same order, agree very closely with one another in reference to size. This element of their organization is not defined within those limits, though the Vertebrata, as a whole, are larger than either Articulata, Mollusks, or Radiata; though Mammalia are larger than Birds, Crustacea larger than Insects; though Cetacea are larger than Herbivora, these larger than Carnivora, etc. The true limit at which, in the organization of animals, size acquires a real importance, is that of families, that is, the groups which are essentially distinguished by their form, as if form and size were correlative as far as the structure of animals is concerned. The representatives of natural families are indeed closely similar in that respect; the extreme differences are hardly anywhere tenfold within these limits, and frequently only double. A few examples, selected among the most natural families, will show this. Omitting mankind, on account of the objections which might be made against the idea that it embraces any original diversity, let us consider the different families of Monkeys, of Bats, of Insectivora, of Carnivora, of Rodents, of Pachyderms, of Ruminants, etc., among Birds, the Vultures, the Eagles, the Falcons, the Owls, the Swallows, the Finches, the Warblers, the Humming Birds, the Doves, the Wrens, the Ostriches, the Herons, the Plovers, the Gulls, the Ducks, the Pelicans; among Reptiles, the Crocodiles, the different families of Chelonians, of Lizards, of Snakes, the Frogs proper, the Toads, etc.; among Fishes, the Sharks and Skates, the Herrings, the Codfishes, the Cyprinodonts, the Chætodonts, the Lophobranchii, the Ostracionts, etc.; among Insects, the Sphingoidæ or the Tineina, the Longicorns or the Coccinellina, the Bomboidæ or the Brachonidæ; among Crustacea, the Cancroidea or the Pinnotheroidæ, the Limuloidæ or the Cypridoidæ, and the Rotifera;[1] among Worms, the Dorsibranchiata or the Naioidæ; among Mollusks, the Stromboidæ or the Buccinoidæ, the Helicinoidæ or the Limnæoidæ, the Chamacea or the Cycladoidæ; among Radiata, the Asterioidæ and the Ophiuroidæ, the Hydroids and the Discophoræ, the Astræoidæ and the Actinioidæ.

Having thus recalled some facts which go to show what are the limits within which size and structure are more directly connected,[2] it is natural to infer, that since size is such an important character of species, and extends distinctly its cycle of relationship to the families or even further, it can as little be supposed to be determined by physical agents as the structure itself with which it is so closely connected, both bearing similar relations to these agents.

Life is regulated by a quantitative element in the structure of all organized beings, which is as fixed and as precisely determined as every other feature depending more upon the quality of the organs or their parts. This shows the more distinctly the presence of a specific, immaterial principle in each kind of animals and plants, as all begin their existence in the condition of ovules of a microscopic size, exhibiting in all a wonderful similarity of structure. And yet these primitive ovules, so identical at first in their physical constitution, never produce any thing different from the parents; all reach respectively, through a succession of unvarying changes, the same final result, the reproduction of a new being identical with the parents. How does it then happen, that, if physical agents have such a powerful influence in shaping the character of organized beings, we see no trace of it in the innumerable instances in which these ovules are discharged in the elements in which they undergo their further development, at a period when the germ they contain,

[1] See DANA'S Crustacea, p. 1409 and 1411.

[2] These remarks about the average size of animals in relation to their structure, cannot fail to meet with some objections, as it is well known, that under certain circumstances, man may modify the normal size of a variety of plants and of domesticated animals, and that even in their natural state occasional instances of extraordinary sizes occur. But this neither modifies the characteristic average, nor is it a case which has the least bearing upon the question of origin or even the maintenance of any species, but only upon individuals, respecting which more will be found in Sect. 16. Moreover, it should not be overlooked that there are limits to these variations, and that though animals and plants may be placed under influences conducive to a more or less voluminous growth, yet it is chiefly under the agency of man, that such changes reach their extremes. (See also Sect. 15.)

has not yet assumed any of those more determined characteristics which distinguish the full-grown animal or the perfect plant? Do physicists know a law of the material world which presents any such analogy to these phenomena, that it could be considered as accounting for them?

In this connection it should be further remembered, that these cycles of size characteristic of different families, are entirely different for animals of different types, though living together under identical circumstances.

SECTION XIV.

RELATIONS BETWEEN THE SIZE OF ANIMALS, AND THE MEDIUMS IN WHICH THEY LIVE.

It has just been remarked, that animals of different types, even when living together, are framed in structures of different size. Yet, life is so closely combined with the elements of nature, that each type shows decided relations, within its own limits, to these elements as far as size is concerned.[1] The aquatic Mammalia, as a whole, are larger than the terrestrial ones; so are the aquatic Birds, and the aquatic Reptiles. In families which are essentially terrestrial, the species which take to the water are generally larger than those which remain permanently terrestrial, as for instance, the Polar Bear, the Beaver, the Coypu, and the Capivara. Among the different families of aquatic Birds, those of their representatives which are more terrestrial in their habits are generally smaller than those which live more permanently in water. The same relation is observed in the different families of Insects which number aquatic and terrestrial species. It is further remarkable, that among aquatic animals, the fresh water types are inferior in size to the marine ones; the marine Turtles are all larger than the largest inhabitants of our rivers and ponds, the more aquatic Trionyx larger than the Emyds and among these the more aquatic Chelydra larger than the true Emys, and these generally larger than the more terrestrial Clemmys or the Cistudo. The class of Fishes has its largest representatives in the sea; fresh water fishes are on the whole dwarfs, in comparison to their marine relatives, and the largest of them, our Sturgeons and Salmons, go to the sea. The same relations obtain among Crustacea; to be satisfied of the fact, we need only compare our Crawfishes with the Lobsters, our Apus with Limulus, etc. Among

[1] GEOFFROY ST. HILAIRE, (ISID.,) Recherches zoologiques et physiologiques sur les variations de la taille chez les Animaux et dans les races humaines, Paris, 1831, 4to. — See also my paper upon the Natural Relations between Animals and the Elements, etc., quoted above, p. 32.

Worms, the Earthworms and Leeches furnish a still wider range of comparisons when contrasted with the marine types. Among Gasteropods and Acephala, this obtains to the same extent; the most gigantic Ampullariae and Anodontae are small in comparison to certain Fusus, Voluta, Tritonium, Cassis, Strombus, or to the Tridacna. Among Radiata even, which are all marine, with the exception of the single genus Hydra, this rule holds good, as the fresh water Hydroids are among the smallest Acalephs known.

This coincidence, upon such an extensive scale, seems to be most favorable to the view that animals are modified by the immediate influence of the elements; yet I consider it as affording one of the most striking proofs that there is no causal connection between them. Were it otherwise, the terrestrial and the aquatic representatives of the same family could not be so similar as they are in all their essential characteristics, which actually stand in no relation whatsoever to these elements. What constitutes the Bear in the Polar Bear, is not its adaptation to an aquatic mode of existence. What makes the Whales Mammalia, bears no relation to the sea. What constitutes Earthworms, Leeches, and Eunice members of one class, has no more connection with their habitat, than the peculiarities of structure which unite Man, Monkeys, Bats, Lions, Seals, Beavers, Mice, and Whales into one class. Moreover, animals of different types living in the same element have no sort of similarity, as to size. The aquatic Insects, the aquatic Mollusks fall in with the average size of their class, as well as the aquatic Reptiles and the aquatic Birds, or the aquatic Mammalia; but there is no common average for either terrestrial or aquatic animals of different classes taken together, and in this lies the evidence that organized beings are independent of the mediums in which they live, as far as their origin is concerned, though it is plain that when created they were made to suit the element in which they were placed.

To me these facts show, that the phenomena of life are manifested in the physical world, and not through or by it; that organized beings are made to conquer and assimilate to themselves the materials of the inorganic world; that they maintain their original characteristics, notwithstanding the unceasing action of physical agents upon them. And I confess I cannot comprehend how beings so entirely independent of these influences, could be produced by them.

SECTION XV.

PERMANENCY OF SPECIFIC PECULIARITIES IN ALL ORGANIZED BEINGS.

It was a great step in the progress of science when it was ascertained that species have fixed characters, and that they do not change in the course of time. But this fact, for which we are indebted to Cuvier,[1] has acquired a still greater importance since it has also been established, that even the most extraordinary changes in the mode of existence and in the conditions under which animals may be placed, have no more influence upon their essential characters than the lapse of time.

The facts bearing upon these two subjects are too well known now to require special illustration. I will, therefore, allude only to a few points, to avoid even the possibility of a misapprehension of my statements. That animals of different geological periods differ specifically, *en masse*, from those of preceding or following formations, is a fact satisfactorily ascertained. Between two successive geological periods, then, changes have taken place among animals and plants. But none of those primordial forms of life, which naturalists call species, are known to have changed during any of these periods. It cannot be denied, that the species of different successive periods are supposed by some naturalists to derive their distinguishing features from changes which have taken place in those of preceding ages; but this is a mere supposition, supported neither by physiological nor by geological evidence, and the assumption that animals and plants may change in a similar manner during one and the same period, is equally gratuitous. On the contrary, it is known by the evidence furnished by the Egyptian monuments, and by the most careful comparison between animals found in the tombs of Egypt with living specimens of the same species obtained in the same country, that there is not the shadow of a difference between them, for a period of about five thousand years. These comparisons, first instituted by Cuvier, have proved, that as far as it has been possible to carry back the investigation, it does not afford the beginning of an evidence that species change in the course of time, if the comparisons be limited to the same great cosmic epoch. Geology only shows that at different periods[2] there have existed

[1] CUVIER, (G.) Recherches sur les ossements fossiles, etc., Nouv. édit. Paris, 1821, 5 vols., 4to., fig., vol. i., sur l'Ibis, p. cxli.

[2] I trust no reader will be so ignorant of the facts here alluded to, as to infer from the use of the word "period" for different eras and epochs of great length, each of which is characterized by different animals, that the differences these animals exhibit, is in itself evidence of a change in the species. The question is, whether any changes take place during one or any of these periods. It is almost incredible how loosely some people will argue upon

different species; but no transition from those of a preceding into those of the following epoch has ever been noticed anywhere; and the question alluded to here is to be distinguished from that of the origin of the differences in the bulk of species belonging to two different geological eras. The question we are now examining involves only the fixity or mutability of species during one epoch, one era, one period in the history of our globe. And nothing furnishes the slightest argument in this point from a want of knowledge of the facts, even though they seem to reason logically. A distinguished physicist has recently taken up this subject of the immutability of species, and called in question the logic of those who uphold it. I will put his argument into as few words as possible, and show, I hope, that it does not touch the case. "Changes are observed from one geological period to another; species which do not exist at an earlier period are observed at a later period, while the former have disappeared; and though each species may have possessed its peculiarities unchanged for a lapse of time, the fact that when long periods are considered, all those of an earlier period are replaced by new ones at a later period, proves that species change in the end, provided a sufficiently long period of time is granted." I have nothing to object to the statement of facts, as far as it goes, but I maintain that the conclusion is not logical. It is true that species are limited to particular geological epochs; it is equally true that, in all geological formations, those of successive periods are different, one from the other. But because they so differ, does it follow that they have changed, and not been exchanged for, or replaced by others? The length of time taken for the operation has nothing to do with the argument. Granting myriads of years for each period, no matter how many or how few, the question remains simply this: When the change takes place, does it take place spontaneously, under the action of physical agents, according to their law, or is it produced by the intervention of an agency not in that way at work before or afterwards? A comparison may explain my view more fully. Let a lover of the fine arts visit a museum arranged systematically, and in which the works of the different schools are placed in chronological order; as he passes from one room to another, he beholds changes as great as those the palæontologist observes in passing from one system of rocks to another. But because these works bear a closer resemblance as they belong to one or the other school, or to periods following one another closely, would the critic be in any way justified in assuming that the earlier works have changed into those of a later period, or to deny that they are the works of artists living and active at the time of their production? The question about the immutability of species is identical with this supposed case. It is not because species have lasted for a longer or shorter time in past ages, that naturalists consider them as immutable, but because in the whole series of geological ages, taking the entire lapse of time which has passed since the first introduction of animals or plants upon earth, not the slightest evidence has yet been produced that species are actually transformed one into the other. We only know that they are different at different periods, as are works of art of different periods and of different schools; but as long as we have no other data to reason upon than those geology has furnished, to this day, it is as unphilosophical and illogical, because such differences exist, to assume that species do change, and have changed, that is, are transformed, or have been transformed, as it would be to maintain that works of art change in the course of time. We do not know how organized beings have originated, it is true; no naturalist can be prepared to account for their appearance in the beginning, or for their difference in different periods; but enough is known to repudiate the assumption of their transmutation, as it does not explain the facts, and shuts out further attempts at proper investigations. See BADEN POWELL'S Essays, quoted above; p. 412, et seq., and Essay 3d, generally.

favor of their mutability; on the contrary, every modern investigation[1] has only gone to confirm the results first obtained by Cuvier, and his views that species are fixed.

It is something to be able to show by monumental evidence, and by direct comparison, that animals and plants have undergone no change for a period of about five thousand years.[2] This result has had the greatest influence upon the progress of science, especially with reference to the consequences to be drawn from the occurrence in the series of geological formations of organized beings as highly diversified in each epoch as those of the present day;[3] it has laid the foundation for the conviction, now universal among well informed naturalists, that this globe has been in existence for innumerable ages, and that the length of time elapsed since it first became inhabited cannot be counted in years. Even the length of the period to which we belong is still a problem, notwithstanding the precision with which certain systems of chronology would fix the creation of man.[4] There are, however, many circumstances which show that the animals now living have been for a much longer period inhabitants of our globe than is generally supposed. It has been possible to trace the formation and growth of our coral reefs, especially in Florida,[5] with sufficient precision to ascertain that it must take about eight thousand years for one of those coral walls to rise from its foundation to the level of the surface of the ocean. There are, around the southernmost extremity of Florida alone, four such reefs concentric with one another, which can be shown to have grown up, one after the other. This gives for the beginning of the first of these reefs an age of over thirty thousand years; and yet the corals by which they were all built up are the same identical species in all of them. These facts, then, furnish as direct evidence as we can obtain in any branch of physical inquiry, that some, at least, of the species of animals now existing, have been in existence over thirty thousand years, and have not undergone the slightest change during the whole of that period.[6] And yet these

[1] KUNTH, Recherches sur les plantes trouvées dans les tombeaux égyptiens, Ann. des scien. nat., vol. viii., 1826, p. 411.

[2] It is not for me to discuss the degree of reliability of the Egyptian chronology; but as far as it goes, it shows that from the oldest periods ascertained, animals have been what they are now.

[3] See my paper upon The Primitive Diversity, etc., quoted above, p. 25.

[4] NOTT & GLIDDON, Types of Mankind, p. 653.

[5] See my paper upon the Reefs of Florida, soon to be published in the Reports of the United States Coast Survey, extracts of which are already printed in the Report for 1851, p. 145.

[6] Those who feel inclined to ascribe the differences which exist between species of different geological periods to the modifying influence of physical agents, and who look to the changes now going on among the living for the support of such an opinion, and may not be satisfied that the facts just mentioned are sufficient to prove the immutability of species, but may still believe that a longer period of time would yet do what thirty thousand years have not done, I beg leave to refer, for further con-

four concentric reefs are only the most distinct of that region; others, less extensively investigated thus far, lie to the northward; indeed, the whole peninsula of Florida consists altogether of coral reefs annexed to one another in the course of time, and containing only fragments of corals and shells, etc., identical with those now living upon that coast. Now, if a width of five miles is a fair average for one coral reef growing under the circumstances under which the concentric reefs of Florida are seen now to follow one another, and this regular succession should extend only as far north as Lake Ogeechobee, for two degrees of latitude, this would give about two hundred thousand years for the period of time which was necessary for that part of the peninsula of Florida which lies south of Lake Ogeechobee to rise to its present southern extent above the level of the sea, and during which no changes have taken place in the character of the animals of the Gulf of Mexico.

It is very prejudicial to the best interests of science to confound questions that are entirely different, merely for the sake of supporting a theory; yet this is constantly done, whenever the question of the fixity of species is alluded to. A few more words upon this point will, therefore, not be out of place here.

I will not enter into a discussion upon the question whether any species is found identically the same in two successive formations, as I have already examined it at full length elsewhere,[1] and it may be settled finally one way or the other, without affecting the proposition now under consideration; for it is plain, that if such identity could be proved, it would only show more satisfactorily how tenacious species are in their character, to continue to live through all the physical changes which have taken place between two successive geological periods. Again, such identity once proved, would leave it still doubtful whether their representatives in two successive epochs are descendants one of the other, as we have already strong evidence in favor of the separate origin of the representatives of the same species in separate geographical areas.[2] The case of closely allied, but different species occurring in successive periods, yet limited respectively in their epochs, affords, in the course of time, a parallel to the case of closely allied, so-called, representative species occupying different areas in space, which no sound naturalist would suppose now to be derived one from the other. There is no more reason to suppose equally allied species following one another in time to be derived one from the other; and all that has been said

sideration, to the charming song of Chamisso, entitled Tragishe Geschichte, and beginning as follows:

's war Einer dem's zu Herzen ging.

[1] AGASSIZ, (L.,) Coquilles tertiaires réputées identiques avec les espèces vivantes, Nouv. Mém. de la Soc. Helv. des sc. nat. Neuchâtel, 1845, vol. 7, 4to. fig.—AGASSIZ, (L.,) Etudes critiques sur les Mollusques fossiles, Neuchâtel, 1831–45, 4to. fig.—AGASSIZ, (L.,) Monographies d'Echinodermes vivans et fossiles, Neuchâtel, 1838–42. 4 nos., 4to. fig.—AGASSIZ, (L.,) Recherches sur les Poissons fossiles, Neuchâtel, 1833–44, 5 vols., 4to., atlas, fol.

[2] See Sect. 10, where the case of representative species is considered.

in preceding paragraphs respecting the differences observed between species occurring in different geographical areas, applies with the same force to species succeeding each other in the course of time.

When domesticated animals and cultivated plants are mentioned as furnishing evidence of the mutability of species, the circumstance is constantly overlooked or passed over in silence, that the first point to be established respecting them, in order to justify any inference from them against the fixity of species, would be to show that each of them has originated from one common stock, which, far from being the case, is flatly contradicted by the positive knowledge we have that the varieties of several of them, at least, are owing to the entire amalgamation of different species.[1] The Egyptian monuments show further that many of those so-called varieties which are supposed to be the product of time, are as old as any other animals which have been known to man; at all events, we have no tradition, no monumental evidence of the existence of any wild animal older than that which represents domesticated animals, already as different among themselves as they are now.[2] It is, therefore, quite possible that the different races of domesticated animals were originally distinct species, more or less mixed now, as the different races of men are. Moreover, neither domesticated animals nor cultivated plants, nor the races of men, are the proper subjects for an investigation respecting the fixity or mutability of species, as all involve already the question at issue in the premises which are assumed in introducing them as evidence in the case. With reference to the different breeds of our domesticated animals, which are known to be produced by the management of man, as well as certain varieties of our cultivated plants, they must be well distinguished from permanent races, which, for aught we know, may be primordial; for breeds are the result of the fostering care of man; they are the product of the limited influence and control the human mind has over organized beings, and not the free product of mere physical agents. They show, therefore, that even the least important changes which may take place during one and the same cosmic period among animals and plants are controlled by an intellectual power, and do not result from the immediate action of physical causes.

So far, then, from disclosing the effects of physical agents, whatever changes are known to take place in the course of time among organized beings appear as the result of an intellectual power, and go, therefore, to substantiate the view that all the differences observed among finite beings are ordained by the action of the Supreme Intellect, and not determined by physical causes. This position is still more strengthened when we consider that the differences which exist between different races of domesticated animals and the varieties of our cultivated plants, as well

[1] Our fowls, for instance.

[2] NOTT & GLIDDON, Types of Mankind, p. 386.

as among the races of men, are permanent under the most diversified climatic influences; a fact, which the extensive migrations of the civilized nations daily proves more extensively, and which stands in direct contradiction to the supposition that such or similar influences could have produced them.

When considering the subject of domestication, in particular, it ought further to be remembered, that every race of men has its own peculiar kinds of domesticated animals and of cultivated plants, which exhibit much fewer varieties among them in proportion as those races of men have had little or no intercourse with other races, than the domesticated animals of those nations which have been formed by the mixture of several tribes.

It is often stated that the ancient philosophers have solved satisfactorily all the great questions interesting to man, and that modern investigations, though they have grasped with new vigor, and illuminated with new light, all the phenomena of the material world, have added little or nothing in the field of intellectual progress. Is this true? There is no question so deeply interesting to man as that of his own origin, and the origin of all things. And yet antiquity had no knowledge concerning it; things were formerly believed either to be from eternity, or to have been created at one time. Modern science, however, can show, in the most satisfactory manner, that all finite beings have made their appearance successively and at long intervals, and that each kind of organized beings has existed for a definite period of time in past ages, and that those now living are of comparatively recent origin. At the same time, the order of their succession and their immutability during such cosmic periods, show no causal connection with physical agents and the known sphere of action of these agents in nature, but argue in favor of repeated interventions on the part of the Creator. It seems really surprising, that while such an intervention is admitted by all, except the strict materialists, for the establishment of the laws regulating the inorganic world, it is yet denied by so many physicists, with reference to the introduction of organized beings at different successive periods. Does this not rather go to show the imperfect acquaintance of these investigators with the conditions under which life is manifested, and with the essential difference there is between the phenomena of the organic and those of the physical world, than to furnish any evidence that the organic world is the product of physical causes?

SECTION XVI.

RELATIONS BETWEEN ANIMALS AND PLANTS AND THE SURROUNDING WORLD.

Every animal and plant stands in certain definite relations to the surrounding world, some however, like the domestic animals and cultivated plants, being capable of adapting themselves to various conditions more readily than others; but even this pliability is a characteristic feature. These relations are highly important in a systematic point of view, and deserve the most careful attention, on the part of naturalists. Yet, the direction zoölogical studies have taken since comparative anatomy and embryology began to absorb almost entirely the attention of naturalists, has been very unfavorable to the investigation of the habits of animals, in which their relations to one another and to the conditions under which they live, are more especially exhibited. We have to go back to the authors of the preceding century,[1] for the most interesting accounts of the habits of animals, as among modern writers there are few who have devoted their chief attention to this subject.[2] So little, indeed, is its importance now appreciated, that the students of this branch of natural history are hardly acknowledged as peers by their fellow investigators, the anatomists and physiologists, or the systematic zoölogists. And yet, without a thorough knowledge of the habits of animals, it will never be possible to ascertain with any degree of precision the true limits of all those species which descriptive zoölogists have of late admitted with so much confidence in their works. And after all, what does it matter to science that thousands of species more or less, should be described and entered in our systems, if we know nothing about them? A very common defect of the works relating to the habits of animals has no doubt contributed to detract from their value and to turn the attention in other directions: their purely anecdotic character, or the circumstance that they are too frequently made the occasion for narrating personal adventures. Nevertheless, the importance of this

[1] RÉAUMUR, (R. ANT. DE,) Mémoires pour servir à l'histoire des Insectes, Paris, 1834–42, 6 vol. 4to. fig. — RÖSEL, (A. J.) Insectenbelustigungen, Nürnberg, 1746–61, 4 vols. 4to. fig. — BUFFON, (G. L. LECLERC DE,) Histoire naturelle générale et particulière, Paris, 1749, 44 vols. 4to. fig.

[2] AUDUBON, (J. J.) Ornithological Biography, or an Account of the Habits of the Birds of the United States of America, Edinburgh, 1831–49, 5 vols. 8vo. — KIRBY, (W.,) and SPENCE, (W.,) An Introduction to Entomology, London, 1818–26, 4 vols. 8vo. fig. — LENZ, (H. O.,) Gemeinnützige Naturgeschichte, Gotha, 1835, 4 vols. 8vo. — RATZENBURG, (J. TH. CH.,) Die Forst-Insekten, Berlin, 1837–44, 3 vols. 4to. fig., and supplement. — HARRIS, (T. W.,) Report on the Insects injurious to Vegetation, Cambridge, 1841, 1 vol. 8vo.; the most important work on American Insects.

kind of investigation can hardly be overrated; and it would be highly desirable that naturalists should turn again their attention that way, now that comparative anatomy and physiology, as well as embryology, may suggest so many new topics of inquiry, and the progress of physical geography has laid such a broad foundation for researches of this kind. Then we may learn with more precision, how far the species described from isolated specimens are founded in nature, or how far they may be only a particular stage of growth of other species; then we shall know, what is yet too little noticed, how extensive the range of variations is among animals, observed in their wild state, or rather how much individuality there is in each and all living beings. So marked, indeed, is this individuality in many families,—and that of Turtles affords a striking example of this kind,—that correct descriptions of species can hardly be drawn from isolated specimens, as is constantly attempted to be done. I have seen hundreds of specimens of some of our Chelonians, among which there were not two identical. And truly, the limits of this variability constitutes one of the most important characters of many species; and without precise information upon this point for every genus, it will never be possible to have a solid basis for the distinction of species. Some of the most perplexing questions in Zoölogy and Palæontology might long ago have been settled, had we had more precise information upon this point, and were it better known how unequal in this respect different groups of the animal kingdom are, when compared with one another. While the individuals of some species seem all different, and might be described as different species, if seen isolated or obtained from different regions, those of other species appear all as cast in one and the same mould. It must be, therefore, at once obvious, how different the results of the comparison of one fauna with another may be, if the species of one have been studied accurately for a long period by resident naturalists, and the other is known only from specimens collected by chance travellers; or, if the fossil representatives of one period are compared with living animals, without both faunæ having first been revised according to the same standard.[1]

Another deficiency, in most works relating to the habits of animals, consists in the absence of general views and of comparisons. We do not learn from them, how far animals related by their structure are similar in their habits, and how far

[1] In this respect, I would remark that most of the cases, in which specific identity has been affirmed between living and fossil species, or between the fossils of different geological periods, belong to families which present either great similarity or extraordinary variability, and in which the limits of species are, therefore, very difficult to establish. Such cases should be altogether rejected in the investigation of general questions, involving fundamental principles, as are untrustworthy observations always in other departments of science. Compare further, my paper upon the primitive diversity and number of animals, quoted above, in which this point is specially considered.

these habits are the expression of their structure. Every species is described as if it stood alone in the world; its peculiarities are mostly exaggerated, as if to contrast more forcibly with all others. Yet, how interesting would be a comparative study of the mode of life of closely allied species; how instructive a picture might be drawn of the resemblance there is in this respect between species of the same genus and of the same family. The more I learn upon this subject, the more am I struck with the similarity in the very movements, the general habits, and even in the intonation of the voices of animals belonging to the same family; that is to say, between animals agreeing in the main in form, size, structure, and mode of development. A minute study of these habits, of these movements, of the voice of animals cannot fail, therefore, to throw additional light upon their natural affinities.

While I thus acknowledge the great importance of such investigations with reference to the systematic arrangement of animals, I cannot help regretting deeply, that they are not more highly valued with reference to the information they might secure respecting the animals themselves, independently of any system. How much is there not left to study with respect to every species, after it is named and classified. No one can read Nauman's Natural History of the German Birds without feeling that natural history would be much further advanced, if the habits of all other animals had been as accurately investigated and as minutely recorded; and yet that work contains hardly any thing of importance with reference to the systematic arrangement of birds. We scarcely possess the most elementary information necessary to discuss upon a scientific basis the question of the instincts and in general the faculties of animals, and to compare them together and with those of man,[1] not only because so few animals have been thoroughly investigated, but because so much fewer still have been watched during their earlier periods of life, when their faculties are first developing; and yet how attractive and instructive this growing age is in every living being! Who could, for instance, believe for a moment longer that the habits of animals are in any degree determined by the circumstances under which they live, after having seen a little Turtle of the genus Chelydra, still enclosed in its egg-shell, which it hardly fills half-way, with a yolk bag as large as itself hanging from its lower surface and enveloped in its amnios and in its allantois, with the eyes shut, snapping as fiercely as if it could bite without killing itself?[2] Who can watch the Sunfish (Pomotis vulgaris) hovering over its eggs and protecting them for weeks, or the Catfish (Pimelodus Catus) move about with its young, like

[1] SCHEITLIN, (P..) Versuch einer vollständigen Thierseelenkunde, Stuttgart und Tübingen, 1840, 2 vols. 8vo. — CUVIER, (FRED..) Résumé analytique des observations sur l'instinct et l'intelligence des animaux, par R. Flourens, Ann. Sc. Nat., 2de sér., vol. 12.

[2] See, Part III., which is devoted to the Embryology of our Turtles.

a hen with her brood, without remaining satisfied that the feeling which prompts them in these acts is of the same kind as that which attaches the Cow to her suckling, or the child to its mother? Who is the investigator, who having once recognized such a similarity between certain faculties of Man and those of the higher animals can feel prepared, in the present stage of our knowledge, to trace the limit where this community of nature ceases? And yet to ascertain the character of all these faculties there is but one road, the study of the habits of animals, and a comparison between them and the earlier stages of development of Man. I confess I could not say in what the mental faculties of a child differ from those of a young Chimpanzee.

Now that we have physical maps of almost every part of the globe,[1] exhibiting the average temperature of the whole year and of every season upon land and sea; now that the average elevation of the continents above the sea, and that of the most characteristic parts of their surface, their valleys, their plains, their table-lands, their mountain systems, are satisfactorily known; now that the distribution of moisture in the atmosphere, the limits of the river systems, the prevailing direction of the winds, the course of the currents of the ocean, are not only investigated, but mapped down, even in school atlases; now that the geological structure of nearly all parts of the globe has been determined with tolerable precision, zoölogists have the widest field and the most accurate basis to ascertain all the relations which exist between animals and the world in which they live.

Having thus considered the physical agents with reference to the share they may have had in calling organized beings into existence, and satisfied ourselves that they are not the cause of their origin, it now remains for us to examine more particularly these relations, as an established fact, as conditions in which animals and plants are placed at the time of their creation, within definite limits of action and reaction between them; for though not produced by the influence of the physical world, organized beings live in it, they are born in it, they grow up in it, they multiply in it, they assimilate it to themselves or feed upon it, they have even a modifying influence upon it within the same limits, as the physical world is subservient to every manifestation of their life. It cannot fail, therefore, to be highly interesting and instructive to trace these connections, even without any reference to the manner in which they were established, and this is the proper sphere of investigation in the study of the habits of animals. The behavior of each kind towards its fellow-beings, and with reference to the conditions of existence in which it is placed, constitutes a field of inquiry of the deepest interest, as extensive as it is

[1] BERGHAUS, Physikalischer Atlas, Gotha, 1838 et seq., fol.—JOHNSTON, (ALEX. KEITH,) Physical Atlas of Natural Phenomena. Edinburgh, 1848, 1 vol. fol.

complicated. When properly investigated, especially within the sphere which constitutes more particularly the essential characteristics of each species of animals and plants, it is likely to afford the most direct evidence of the unexpected independence of physical influences of organized beings, if I mistake not the evidence I have myself been able to collect. What can there be more characteristic of different species of animals than their motions, their plays, their affections, their sexual relations, their care of their young, the dependence of these upon their parents, their instincts, etc., etc.; and yet there is nothing in all this which depends in the slightest degree upon the nature or the influence of the physical conditions in which they live. Even their organic functions are independent of these conditions to a degree unsuspected, though this is the sphere of their existence which exhibits the closest connections with the world around.

Functions have so long been considered as the test of the character of organs, that it has almost become an axiom in comparative anatomy and physiology, that identical functions presuppose identical organs. Most of our general works upon comparative anatomy are divided into chapters according to this view. And yet there never was a more incorrect principle, leading to more injurious consequences, more generally adopted. That naturalists should not long ago have repudiated it, is the more surprising as every one must have felt again and again how unsound it is. The organs of respiration and circulation of fishes afford a striking example. How long have not their gills been considered as the equivalent of the lungs of the higher Vertebrata, merely because they are breathing organs; and yet these gills are formed in a very different way from the lungs; they bear very different relations to the vascular system; and it is now known that they may exist simultaneously with lungs, as in some full-grown Batrachians, and, in the earlier embryonic stages of development, in all Vertebrata. There can no longer be any doubt now, that they are essentially different organs, and that their functions afford no test of their nature and cannot constitute an argument in favor of their organic identity. The same may be said of the vascular system of the fishes. Cuvier[1] described their heart as representing the right auricle and the right ventricle, because it propels the blood it contains to the gills, in the same manner as the right ventricle propels the blood to the lungs of the warm blooded animals; yet embryology has taught us that such a comparison based upon the special relations of the heart of fishes, is unjustifiable. The air sacs of certain spiders have also been considered as lungs, because they perform similar respiratory functions, and yet they are only modified tracheæ,[2] which are constructed upon such a peculiar plan, and stand in

[1] CUVIER, (G.,) Règn. Anim., 2de édit., vol. 2, p. 122.

[2] LEUCKARDT, (R.,) Ueber den Bau und die Bedeutung der sogenannten Lungen bei den Arach-

such different relations to the peculiar kind of blood of the Articulata,[1] that no homology can be traced between them and the lungs of Vertebrata, no more than between the so-called lungs of the air breathing Mollusks, whose aërial respiratory cavity is only a modification of the peculiar kind of gills observed in other Mollusks. Examples might easily be multiplied; I will, however, only allude further to the alimentary canal of Insects and Crustacea, with its glandular appendages, formed in such a different way from that of Vertebrata, or Mollusks, or Radiata, to their legs and wings, etc., etc. I might allude also to what has been called the foot in Mollusks, did it not appear like pretending to suppose that any one entertains still an idea that such a name implies any similarity between their locomotive apparatus and that of Vertebrata or Articulata, and yet, the very use of such a name misleads the student, and even some of the coryphees of our science have not freed themselves of such and similar extravagant comparisons, especially with reference to the solid parts of the frame of the lower animals.[2]

The identification of functions and organs was a natural consequence of the prevailing ideas respecting the influence physical agents were supposed to have upon organized beings. But as soon as it is understood, how different the organs may be, which in animals perform the same function, organization is at once brought into such a position to physical agents as makes it utterly impossible to maintain any genetic connection between them. A fish, a crab, a mussel, living in the same waters, breathing at the same source, should have the same respiratory organs, if the elements in which these animals live had any thing to do with shaping their organization. I suppose no one can be so short-sighted, as to assume that the same physical agents acting upon animals of different types, must produce, in each, peculiar organs, and not to perceive that such an assumption implies the very existence of these animals, independently of the physical agents. But this mistake recurs so constantly in discussions upon this and similar topics, that, trivial as it is, it requires to be rebuked.[3] On the contrary, when acknowledging an intellectual conception,

niden, in SIEBOLD und KÖLLIKER's Zeitschrift, f. wiss. Zool., 1849, I., p. 246.

[1] BLANCHARD, (EM.,) De la circulation dans les Insectes, Compt. Rend., 1847, vol. 24, p. 870. — AGASSIZ, (L.,) On the Circulation of the Fluids in Insects, Proc. Amer. Asso., for 1849, p. 140.

[2] CARUS, (C. G.,) Von den Ur-Theilen des Knochen- und Schalengerüstes, Leipzig, 1828, 1 vol., fol., p. 61–89.

[3] I hope the day is not far distant, when zoölogists and botanists will equally disclaim having shared in the physical doctrines more or less prevailing now, respecting the origin and existence of organized beings. Should the time come when my present efforts may appear like fighting against windmills, I shall not regret having spent so much labor in urging my fellow-laborers in a right direction; but at the same time, I must protest now and for ever, against the bigotry spreading in some quarters, which would press upon science, doctrines not immediately flowing from scientific premises and check its free progress.

as the preliminary step in the existence not only of all organized beings, but of every thing in nature, how natural to find that while diversity is introduced in the plan, in the complication and the details of structure of animals, their relations to the surrounding media are equally diversified, and consequently the same functions may be performed by the most different apparatus!

SECTION XVII.

RELATIONS OF INDIVIDUALS TO ONE ANOTHER.

The relations in which individuals of the same species of animals stand to one another are not less determined and fixed than the relations of species to the surrounding elements, which we have thus far considered. The relations which individual animals bear to one another are of such a character, that they ought long ago to have been considered as proof sufficient that no organized being could ever have been called into existence by another agency than the direct intervention of a reflective mind. It is in a measure conceivable that physical agents might produce something like the body of the lowest kinds of animals or plants, and that under identical circumstances the same thing may have been produced again and again, by the repetition of the same process; but that upon closer analysis of the possibilities of the case, it should not have at once appeared how incongruous the further supposition is, that such agencies could delegate the power of reproducing what they had just called into existence, to those very beings, with such limitations, that they could never reproduce any thing but themselves, I am at a loss to understand. It will no more do to suppose that from simpler structures such a process may end in the production of the most perfect, as every step implies an addition of possibilities not even included in the original case. Such a delegation of power can only be an act of intelligence; while between the production of an indefinite number of organized beings, as the result of a physical law, and the reproduction of these same organized beings by themselves, there is no necessary connection. The successive generations of any animal or plant cannot stand, as far as their origin is concerned, in any causal relation to physical agents, if these agents have not the power of delegating their own action to the full extent to which they have already been productive in the first appearance of these beings; for it is a physical law that the resultant is equal to the forces applied. If any new being has ever been produced by such agencies, how could the successive generations enter, at the time of their birth, into the same relations to these agents, as their ancestors, if these beings had not in themselves the faculty of sustaining their character, in spite of these agents? Why, again, should animals and plants at once begin to decompose under the very influence of all those agents which have been subservient to the maintenance of their life, as soon as life ceases, if life is limited or determined by them?

There exist between individuals of the same species relations far more complicated than those already alluded to, which go still further to disprove any possibility of causal dependence of organized beings upon physical agents. The relations upon which the maintenance of species is based, throughout the animal kingdom, in the universal antagonism of sex, and the infinite diversity of these connections in different types, have really nothing to do with external conditions of existence; they indicate only relations of individuals to individuals, beyond their connections with the material world in which they live. How, then, could these relations be the result of physical causes, when physical agents are known to have a specific sphere of action, in no way bearing upon this sphere of phenomena?

For the most part, the relations of individuals to individuals are unquestionably of an organic nature, and, as such have to be viewed in the same light as any other structural feature; but there is much, also, in these connections that partakes of a psychological character, taking this expression in the widest sense of the word.

When animals fight with one another, when they associate for a common purpose, when they warn one another in danger, when they come to the rescue of one another, when they display pain or joy, they manifest impulses of the same kind as are considered among the moral attributes of man. The range of their passions is even as extensive as that of the human mind, and I am at a loss to perceive a difference of kind between them, however much they may differ in degree and in the manner in which they are expressed. The gradations of the moral faculties among the higher animals and man are, moreover, so imperceptible, that to deny to the first a certain sense of responsibility and consciousness, would certainly be an exaggeration of the difference between animals and man. There exists, besides, as much individuality, within their respective capabilities, among animals as among men, as every sportsman, or every keeper of menageries, or every farmer and shepherd can testify who has had a large experience with wild, or tamed, or domesticated animals.[1]

This argues strongly in favor of the existence in every animal of an immaterial

[1] See J. E. RIDINGER's various works illustrative of Game Animals, which have appeared under different titles, in Augsburg, from 1729 to 1778.—GEOFFROY ST. HILAIRE, et CUVIER, (FR.,) Histoire naturelle des Mammifères, Paris, 1820–35, 3 vols. fol.—LENZ, (H. O.,) Gemeinnützige Naturgeschichte, Gotha, 1835, 4 vols. 8vo.—BINGLEY, (W.,) Animal Biography, London, 1803, 3 vols. 8vo.

principle similar to that which, by its excellence and superior endowments, places man so much above animals.[1] Yet the principle exists unquestionably, and whether

[1] It might easily be shown that the exaggerated views generally entertained of the difference existing between man and monkeys, are traceable to the ignorance of the ancients, and especially the Greeks, to whom we owe chiefly our intellectual culture, of the existence of the Orang-Outang and the Chimpanzee. The animals most closely allied to man known to them were the Red Monkey, *κῆβος*, the Baboon, *κυνοκέφαλος*, and the Barbary Ape, *πίθηκος*. A modern translation of Aristotle, it is true, makes him say that monkeys form the transition between man and quadrupeds; (ARISTOTELES, Naturgeschichte der Thiere, von DR. F. STRACK, Frankfurt-am-Main, 1816, p. 65;) but the original says no such thing. In the History of Animals, Book 2, Chap. V., we read only, *ἔνια δὲ τῶν ζώων ἐπαμφοτερίζει τὴν φύσιν τῷ τε ἀνθρώπῳ καὶ τοῖς τετράποσιν.* There is a wide difference between "partaking of the nature of both man and the quadrupeds," and "forming a transition between man and the quadrupeds." The whole chapter goes on enumerating the structural similarity of the three monkeys named above with man, but the idea of a close affinity is not even expressed, and still less that of a transition between man and the quadrupeds. The writer, on the contrary, dwells very fully upon the marked differences they exhibit, and knows as well as any modern anatomist has ever known, that monkeys have four hands. *ἔχει δὲ καὶ βραχίονας, ὥσπερ ἄνθρωπος, ... ἰδίους δὲ τοὺς πόδας. εἰσὶ γὰρ οἷον χεῖρες μεγάλαι. Καὶ οἱ δάκτυλοι ὥσπερ οἱ τῶν χειρῶν, ὁ μέγας μακρότατος· καὶ τὸ κάτω τοῦ ποδὸς χειρὶ ὅμοιον, πλὴν ἐπὶ τὸ μῆκος τὸ τῆς χειρὸς ἐπὶ τα ἔσχατα τεῖνον καθάπερ θέναρ. Τοῦτο δὲ ἐπ' ἄκρου σκληρότερον, κακῶς και ἀμυδρῶς μιμούμενον πτέρναν.*

It is strange that these clear and precise distinctions should have been so entirely forgotten in the days of Linnæus that the great reformer in Natural History had to confess, in the year 1746, that he knew no character by which to distinguish man from the monkeys. Fauna Suecica, Præfat. p. 2. "Nullum characterem adhuc eruere potui, unde homo a simia internoscatur." But it is not upon structural similarity or difference alone that the relations between man and animals have to be considered. The psychological history of animals shows that as man is related to animals by the plan of his structure, so are these related to him by the character of those very faculties which are so transcendent in man as to point at first to the necessity of disclaiming for him completely any relationship with the animal kingdom. Yet the natural history of animals is by no means completed after the somatic side of their nature has been thoroughly investigated; they, too, have a psychological individuality, which, though less fully studied, is nevertheless the connecting link between them and man. I cannot, therefore, agree with those authors who would disconnect mankind from the animal kingdom, and establish a distinct kingdom for man alone, as Ehrenberg (Das Naturreich des Menschen, Berlin, 1835, fol.) and lately I. Geoffroy St. Hilaire, (Hist. nat. générale, Paris, 1856, Tome 1, Part 2, p. 167,) have done. Compare, also, Chap. II., where it is shown for every kind of groups of the animal kingdom that the amount of their difference one from the other never affords a sufficient ground for removing any of them into another category. A close study of the dog might satisfy every one of the similarity of his impulses with those of man, and those impulses are regulated in a manner which discloses psychical faculties in every respect of the same kind as those of man; moreover, he expresses by his voice his emotions and his feelings, with a precision which may be as intelligible to man as the articulated speech of his fellow men. His memory is so retentive that it frequently baffles that of man. And though all these faculties do not make a philosopher of him, they certainly place him in that respect upon a level with a considerable proportion of poor humanity. The intelligibility of the voice of animals to one another, and all their actions connected with such calls are also a strong argument of their perceptive power, and of their ability to act sponit be called soul, reason, or instinct, it presents in the whole range of organized beings a series of phenomena closely linked together; and upon it are based not only the higher manifestations of the mind, but the very permanence of the specific differences which characterize every organism. Most of the arguments of philosophy in favor of the immortality of man apply equally to the permanency of this principle in other living beings. May I not add, that a future life, in which man should be deprived of that great source of enjoyment and intellectual and moral improvement which result from the contemplation of the harmonies of an organic world, would involve a lamentable loss, and may we not look to a spiritual concert of the combined worlds and all their inhabitants in presence of their Creator as the highest conception of paradise?

SECTION XVIII.

METAMORPHOSES OF ANIMALS.

The study of embryology is of very recent date; the naturalists of the past century, instead of investigating the phenomena accompanying the first formation and growth of animals, were satisfied with vague theories upon reproduction.[1] It is true

taneously and with logical sequence in accordance with these perceptions. There is a vast field open for investigation in the relations between the voice and the actions of animals, and a still more interesting subject of inquiry in the relationship between the cycle of intonations which different species of animals of the same family are capable of uttering, which, as far as I have as yet been able to trace them, stand to one another in the same relations as the different, so-called, families of languages (SCHLEGEL, (FR.,) Ueber die Sprache und Weisheit der Indier, Heidelberg, 1808, 1 vol. 8vo. — HUMBOLDT, (W. v.,) Ueber die Kawi-Sprache, auf der Insel Java, Berlin, 1836–39, 3 vols. 4to. Abh. Ak. d. Wissensch. — STEINTHAL, (H.,) Grammatik, Logik und Psychologie, Berlin, 1855, 1 vol. 8vo.) in the human family. All the *Canina* bark; the howling of the wolves, the barking of the dogs and foxes, are only different modes of barking, comparable to one another in the same relation as the monosyllabic, the agglutinating, and the inflecting languages. The *Felidæ* mew: the roaring of the lion is only another form of the mewing of our cats and the other species of the family. The *Equina* neigh or bray: the horse, the donkey, the zebra, the dow, do not differ much in the scale of their sounds. Our cattle, and the different kinds of wild bulls, have a similar affinity in their intonations; their lowing differs not in kind, but only in the mode of utterance. Among birds, this is, perhaps, still more striking. Who does not distinguish the note of any and every thrush, or of the warblers, the ducks, the fowls, etc., however numerous their species may be, and who can fail to perceive the affinity of their voices? And does this not indicate a similarity also in their mental faculties?

[1] BUFFON, (G. L. LECLERC DE,) Discours sur la nature des Animaux, Genève, 1754, 12mo.; also in his Oeuvres complètes, Paris, 1774–1804, 36 vols. 4to.

the metamorphoses of Insects became very early the subject of most remarkable observations,[1] but so little was it then known that all animals undergo great changes from the first to the last stages of their growth, that metamorphosis was considered a distinguishing character of Insects. The differences between Insects, in that respect, are however already so great, that a distinction was introduced between those which undergo a complete metamorphosis, that is to say, which appear in three successive different forms, as larvæ, pupæ, and perfect insects, and those with an incomplete metamorphosis, or whose larvæ differ little from the perfect insect. The range of these changes is yet so limited in some insects, that it is not only not greater, but is even much smaller than in many representatives of other classes. We may, therefore, well apply the term metamorphosis to designate all the changes which animals undergo, in direct and immediate succession,[2] during their growth, whether these changes are great or small, provided they are correctly qualified for each type.

The study of embryology, at first limited to the investigation of the changes which the chicken undergoes in the egg, has gradually extended to every type of the animal kingdom; and so diligent and thorough has been the study, that the first author who ventured upon an extensive illustration of the whole field, C. E. von Baer, has already presented the subject in such a clear manner, and drawn general conclusions so accurate and so comprehensive, that all subsequent researches in this department of our science, may be considered only as a further development of the facts first noticed by him and of the results he has already deduced from them.[3] It was he who laid the foundation for the most extensive

[1] SWAMMERDAM, (J.,) Biblia Naturæ, sive Historia Insectorum, etc., Lugduni-Batavorum, 1737–38, 3 vols. fol. fig. — REAUMUR, (R. ANT. DE,) Mémoires pour servir à l'Histoire des Insectes, Paris, 1734–42, 6 vol. 4to. fig. — ROESEL VON ROSENHOF, (A. J.,) Insectenbelustigungen, Nürnberg, 1746–61, 4 vols. 4to. fig.

[2] I say purposely, "in direct and immediate succession," as the phenomena of alternate generation are not included in metamorphosis, and consist chiefly in the production of new germs, which have their own metamorphosis; while metamorphosis proper relates only to the successive changes of one and the same germ.

[3] Without referring to the works of older writers, such as DeGraaf, Malpighi, Haller, Wolf, Meckel, Tiedemann, etc., which are all enumerated with many others in BISCHOFF's article "Entwickelungsgeschichte," in WAGNER's Handwörterbuch der Physiologie, vol. 1, p. 860, I shall mention hereafter, chiefly those published since, under the influence of Döllinger, this branch of science has assumed a new character: — BAER, (C. E. v.,) Ueber Entwickelungsgeschichte der Thiere, Königsberg, 1828–37, 2 vols. 4to. fig. The most important work yet published. The preface is a model of candor and truthfulness, and sets the merits of Döllinger in a true and beautiful light. As text-books, I would quote, BURDACH, (C. F.,) Die Physiologie als Erfahrungswissenschaft, Leipzig, 1829–40, 6 vols. 8vo.; French, Paris, 1837–41, 9 vols. 8vo. — MÜLLER, (J.,) Handbuch der Physiologie des Menschen, Coblenz, 1843, 2 vols. 8vo. 4th edit.; Engl. by W. BALY, London, 1837, 8vo. — WAGNER, (R.,) Lehrbuch der Physiologie, Leip-

generalizations respecting the mode of formation of animals; for he first discovered, in 1827, the ovarian egg of Mammalia, and thus showed for the first time, that there is no essential difference in the mode of reproduction of the so-called viviparous and oviparous animals, and that man himself is developed in the same manner as the animals. The universal presence of eggs in all animals and the unity of their structure, which was soon afterwards fully ascertained, constitute, in my opinion, the greatest discovery of modern times in the natural sciences.[1]

It was, indeed, a gigantic step to demonstrate such an identity in the material basis of the development of all animals, when their anatomical structure was already known to exhibit such radically different plans in their full-grown state. From that time a more and more extensive investigation of the manner in which the first germ is formed in these eggs, and the embryo develops itself; how its organs grow gradually out of a homogeneous mass; what changes, what complications, what connections, what functions they exhibit at every stage; how in the end the young animal assumes its final form and structure, and becomes a new, independent being, could not fail to be the most interesting subject of inquiry. To ascertain all this, in as many animals as possible, belonging to the most different types of the animal kingdom, became soon the principal aim of all embryological investigations; and it can truly be said, that few sciences have advanced with such astonishing rapidity, and led to more satisfactory results.

For the actual phases of the mode of development of the different types of the animal kingdom, I must refer to the special works upon this subject,[2] no general

zig, 1839–42, 2 vols. 8vo. — VALENTIN, (G.,) Handbuch der Entwickelungsgeschichte, etc., Berlin, 1835, 1 vol. 8vo. — Lehrbuch der Physiologie des Menschen, Braunschweig, 1843, 2 vols. 8vo. — LONGET, (F. A.,) Traité de Physiologie, Paris, 1850, 2 vols. 8vo. — KÖLLIKER, (ALB.,) Microscopische Anatomie des Menschen, Leipzig, 1840–54, 2 vols. 8vo. fig. — See also OWEN'S Lectures, etc., SIEBOLD und STANNIUS'S Lehrbuch, and CARUS'S Morphologie, q. a. p. 27, and p. 18. I might further quote almost every modern text-book on physiology, but most of them are so evidently mere compilations, exhibiting no acquaintance with the subject, that I omit purposely to mention any other elementary works.

[1] BAER, (C. E. a,) De Ovi Mammalium et Hominis Genesi, Königsberg, 1827, 4to., fig. — PURKINJE, (J. E.) Symbolæ ad ovi avium historiam ante incubationem, Lipsiæ, 1830, 4to. fig. — WAGNER, (R.,) Prodromus Historiæ generationis Hominis atque Animalium, etc., Lipsiæ, 1836, 1 vol., fol., fig. — Icones physiologicæ, Lipsiæ, 1839, 4to. fig.

[2] The limited attention, thus far paid in this country to the study of Embryology, has induced me to enumerate more fully the works relating to this branch of science, than any others, in the hope of stimulating investigations in that direction. There exist upon this continent a number of types of animals, the embryological illustration of which would add immensely to the stock of our science; such are the Opossum, the Ichthyoid Batrachians, the Lepidosteus, the Amia, etc., not to speak of the opportunities which thousands of miles of sea-coast, everywhere easily accessible, afford for embryological investigations, from the borders of the Arctics to the Tropics. In connection with Embryology the question of Individuality comes up naturally.

treatise embracing the most recent investigations having as yet been published; and I must take it for granted, that before forming a definite opinion upon the comparisons instituted hereafter between the growth of animals, and the structural gradation among full-grown animals, or the order of succession of the fossils characteristic of different geological periods, the necessary information respecting these changes has been gathered by my readers, and sufficiently mastered to enable them to deal with it freely.

The embryology of Polypi has been very little studied thus far; what we know of the embryonic growth of these animals relates chiefly to the family of Actinoids.[1] When the young is hatched, it has the form of a little club-shaped or pear-shaped body, which soon assumes the appearance of the adult, from which it differs only by having few tentacles. The mode of ramification and the multiplication by buds have, however, been carefully and minutely studied in all the families of this class.[2] Acalephs present phenomena so peculiar, that they are discussed hereafter in a special section. Their young[3] are either polyplike or resemble more immediately

See upon this subject:— LEUCKART, (RUD.,) Ueber den Polymorphismus der Individuen oder die Erscheinung der Arbeitstheilung in der Natur, Giessen, 1851, 4to.—REICHERT, (C. B.,) Die monogene Fortpflanzung, Dorpat, 1852.—HUXLEY, (TH. H.,) Upon Animal Individuality, Ann. and Mag. Nat. Hist. 2d ser., 1852, vol. 9, p. 507.—FORBES, (ED.,) On the supposed Analogy between the Life of an Individual and the Duration of a Species, Ann. and Mag. Nat. Hist., 2d ser., 1852, vol. 10, p. 59. —BRAUN, (AL.,) Das Individuum der Pflanze, q. a. —Betrachtungen über die Erscheinung der Verjüngung in der Natur, *Freiburg, 1849, 4to. fig.*

[1] SARS, (M.,) Beskrivelser og Jagttagelser over nogle maerkelige eller nye i Havet ved den Bergenske Kyst levende Dyr, etc., Bergen, 1835, 4to. —Fauna littoralis Norvegiæ, Christiania, 1846, fol. fig.—RATHKE, (H.,) in Burdach's Physiologie, vol. 2d, 2d *edit. p. 215.*—*Zur* Morphologie, Reisebemerkungen aus Taurien, Riga und Leipzig, 1837, 4to., fig.—AGASSIZ, (L.,) Twelve Lectures, etc., p. 40, et seq.

[2] See DANA'S Zoophytes, and MILNE-EDWARDS et HAIME, Recherches, etc., q. a. p. 31, note 2.

[3] SIEBOLD, (C. TH. E. v.,) *Beiträge zur* Naturgeschichte der wirbellosen Thiere, Dantzig, 1839, 4to. p. 29.—LOVEN, (S. L.) Beitrag zur Kenntniss der Gattungen Campanularia und Syncoryne, Wiegm. Arch., 1837, p. 249 and 321; French Ann. Sc. n. 2de sér., vol. 15, p. 157.—SARS, (M.,) Beskrivelser, q. a.—Fauna littoralis, q. a.—NORDMANN, (AL. v.,) Sur les changements que l'âge apporte dans la manière d'être des Campanulaires, Comptes-Rendus, 1834, p. 709.—STEENSTRUP, (J.,) Ueber den Generations-Wechsel oder die Fortpflanzung und Entwickelung durch abwechselnde Generationen, Uebers, von LORENZEN, Kopenh. 1842, 8vo., fig.; Engl. by G. BUSK, (Ray Society,) London, 1845, 8vo.—VANBENEDEN, (P. J.,) *Mémoire sur les Campanulaires* de la côte d'Ostende, etc., Mém. Ac. Brux. 1843, vol. 17, 4to. fig.—Recherches sur l'Embryogénie des Tubulaires, etc., *Mém. Ac. Brux.* 1844, 4to. fig.—DUJARDIN, (FEL.,) Observations sur un nouveau genre de Médusaires (Cladonema,) provenant de la métamorphose des Syncorynes, Ann. Sc. n. 2de sér. 1843, vol. 20, p. 370.—Mémoire sur le développement des Médusaires et des Polypes Hydraires, Ann. Sc. n. 3e sér., 1845, vol. 4, p. 257. —WILL, (J. G. FR.,) Horæ tergestinæ, Leipzig, 1844, 4to. fig.—FREY, (H.,) und LEUCKART, (R.,) Beiträge zur Kenntniss wirbelloser Thiere, Braunschweig, 1847, 4to. fig.—DALYELL, (SIR J. G.,) Rare

the type of their class. Few multiply in a direct, progressive development. As to Echinoderms, they have for a long time almost entirely escaped the attention of Embryologists, but lately J. Müller has published a series of most important investigations upon this class,[1] disclosing a wonderful diversity in the mode of their develop-

and Remarkable Animals of Scotland, etc., London, 1847, 2 vols. 4to. fig. — FORBES, (ED.,) Monograph of the British Naked-eyed Medusæ, London, 1847, 1 vol. fol. fig. (Ray Society.) — On the Morphology of the Reproductive System of Sertularian Zoophytes, etc., Ann. and Mag. Nat. Hist., 1844, vol. 14, p. 385. — AGASSIZ, (L.,) Twelve Lectures, etc., q. a. — DESOR, (ED.,) Lettre sur la génération médusipare des Polypes Hydraires, Ann. Sc. Nat., 3e sér., 1849, vol. 12, p. 204. — KROHN, (A.,) Bemerkungen über die Geschlechtsverhältnisse der Sertularinen, Müller's Arch., 1843, p. 174. — Ueber die Brut des Cladonema radiatum und deren Entwickelung zum Stauridium, Müller's Arch., 1853, p. 420. — Ueber Podocoryne carnea Sars und die Fortpflanzungsweise ihrer medusenartigen Sprösslinge, Wiegm. Arch., 1851, I., p. 263. — Ueber einige niedere Thiere, Müller's Arch., 1853, p. 137. — Ueber die frühesten Entwickelungsstufen der Pelagia noctiluca, Müller's Arch., 1855, p. 491. — KÖLLIKER, (A.,) Die Schwimmpolypen, etc., q. a. — BUSCH, (W.,) Beobachtungen über Anatomie und Entwickelungsgeschichte einiger wirbelloser Seethiere, Berlin, 1851, 4to. fig. pp. 1, 25 and 30. — GEGENBAUER, KÖLLIKER und MÜLLER, Bericht über einige im Herbste 1852 in Messina angestellte anatomische Untersuchungen, Zeitsch. f. wiss. Zool., vol. 4, p. 299. — GEGENBAUER, (C.,) Ueber die Entwickelung von Doliolum, der Scheibenquallen und von Sagitta, Zeitsch. f. wiss. Zool., 1853, p. 13. — Beiträge zur nähern Kenntniss der Schwimmpolypen (Siphonophoren,) Zeitsch. f. wiss. Zool., 1853, vol. 5, p. 285. — Ueber Diphyes turgida, etc., Zeitsch. f. wiss. Zool., 1853, vol. 5, p. 442. — Ueber den Entwickelungscyclus von Doliolum, etc., Zeitsch. f. wiss. Zool., 1855, vol. 7, p. 283. — FRANTZIUS, (AL. V.,) Ueber die Jungen der Cephea, Zeitsch. f. wiss. Zool., vol. 4, p. 118. — MÜLLER, (J.,) Ueber eine eigenthümliche Meduse des Mittelmeeres und ihren Jugendzustand, Müller's Arch., 1851, p. 272. — SCHULTZE, (M.,) Ueber die männlichen Geschlechtstheile der Campanularia geniculata, Müller's Arch., 1850, p. 53. — HINCKS, (TH.,) Notes on the Reproduction of the Campanulariadæ, etc., Ann. and Mag. Nat. Hist., 2d ser., 1852, vol. 10, p. 81. — Further Notes on British Zoophytes, Ann. and Mag. Nat. Hist., 1853, vol. 15, p. 127. — ALLMAN, (G. J.,) On Hydroids, Rep. Brit. Ass. Adv. Sc., 1852, p. 50. — DERBES, (A.,) Note sur les organes reproducteurs et l'embryogénie du Cyanea chrysaora, Ann. Sc. Nat., 3e sér., 1850, vol. 13, p. 377. — VOGT, (C.,) Ueber die Siphonophoren, Zeitsch. f. wiss. Zool., 1852, vol. 3, p. 522. — HUXLEY, (TH. H.,) On the Anatomy and Affinities of the Family of the Medusæ, Philos. Trans. Roy. Soc., 1849, II., p. 413. — An Account of Researches into the Anatomy of the Hydrostatic Acalephæ, Proc. Brit. Ass. Adv. Sc., 1851, p. 78. — LEUCKARDT, (R.,) Zoologische Untersuchungen, Giessen, 1853–54, 4to. fig. 1st Fasc. — Zur nähern Kenntniss der Siphonophoren von Nizza, Wiegm. Arch., 1854, p. 249. — STIMPSON, (W.,) Synopsis of the Marine Invertebrata of Grand Manan, Smithson. Contrib., 1853, 4to. fig. — LEIDY, (JOS.,) Contributions towards a Knowledge of the Marine Invertebrate Fauna, etc., Journ. Acad. Nat. Sc. Philad., 2d ser. 1855, vol. 3, 4to. fig. — See also below, Sect. 20.

[1] Beskrivelser, etc., p. 37. — Ueber die Entwickelung der Seesterne, Wiegm. Arch., 1844, I., p. 169, fig. — Fauna littoralis, etc., p. 47. — MÜLLER, (J.,) Ueber die Larven u. die Metamorphose der Ophiuren u. Seeigel, Akad. d. Wiss., Berlin, 1848. — Ueber die Larven u. die Metamorphose der Echinodermen, 2te Abh., Ak. d. Wiss., Berlin, 1849. — Ueber die Larven u. die Metamorphose der Holothurien u. Asterien, Ak. d. Wiss., Berlin, 1850. — Ueber die Larven u. die Metamorphose der Echinodermen, 4te Abh., Ak. d. Wiss., Berlin, 1852. — Ueber die Ophiurenlarven des Adriatischen Meeres,

ment, not only in the different orders of the class, but even in different genera of the same family. The larvæ of many have a close resemblance to diminutive Ctenophoræ, and may be homologized with this type of Acalephs.

As I shall hereafter refer frequently to the leading divisions of the animal kingdom, I ought to state here, that I do not adopt some of the changes which have been proposed lately in the limitation of the classes, and which seem to have been pretty generally received with favor. The undivided type of Radiata appears to me as one of the most natural branches of the animal kingdom, and I consider its subdivision into Coelenterata and Echinodermata, as an exaggeration of the anatomical differences observed between them. As far as the plan of their structure is concerned, they do not differ at all, and that structure is throughout homological. In this branch I recognize only three classes, *Polypi*, *Acalephæ*, and *Echinodermata*. The chief difference between the two first lies in the radiating partitions of the main cavity of the Polypi, supporting the reproductive organs; moreover, the digestive cavity in this class consists of an inward fold of the upper aperture of the common sac of the body, while in Acalephs there exist radiating tubes, at least in the *proles medusina*, which extend to the margin of the body where they anastomoze, and the digestive cavity is hollowed out of the gelatinous mass of the body. This is equally true of the Hydroids, the Medusæ proper, and the Ctenophoræ; but nothing of the kind is observed among Polypi. Siphonophoræ, whether their *proles medusina* becomes free or not, and Hydroids agree in having, in the *proles medusina*, simple radiating tubes, uniting into a single circular tube around the margin of the bell-shaped disk. These two groups, constitute together, one natural order, in contradistinction from the Covered-eyed Medusæ, whose radiating tubes ramify towards the margin and form a complicated net of anastomoses. Morphologically, the *proles polypoidea* of the Acalephs, is as completely an Acaleph, as their

Ak. d. Wiss., Berlin, 1852. — Ueber den allgemeinen Plan in der Entwickelung der Echinodermen, Ak. d. Wiss., Berlin, 1853. — Ueber die Gattungen der Seeigellarven, 7te Abh., Ak. d. Wiss., 1855. — Ueber den Canal in den Eiern der Holothurien, Müller's Arch., 1854, p. 60. — French abstracts of these papers may be found in Ann. Sc. Nat., 3e sér., 1852 and '53, vols. 17, 19, and 20; An English account is published by HUXLEY, (TH. H.) Report upon the Researches of Prof. Müller into the Anatomy and Development of the Echinoderms, Ann. and Mag. Nat. Hist., 2d ser., vol. 8, 1851, p. 1. — KOREN und DANIELSSEN in Nyt Magazin for Naturvid. vol. 5, p. 253, Christiania, 1847; Ann. Sc. Nat. 1847, p. 347. — AGASSIZ, (L.,) Twelve Lectures, etc., p. 13. — DERBES, (A.,) Sur la formation de l'embryon chez l'oursin comestible, Ann. Sc. Nat., 3e sér., vol. 8, p. 80. — BUSH, (W.,) Beobachtungen, etc., q. a. — Ueber die Larve der Comatula, Müller's Arch. 1849, p. 400. — KROHN, (A.,) Ueber die Entwickelung der Seesterne und Holothurien, Müller's Arch., 1853, p. 317. — Ueber die Entwickelung einer lebendig gebährenden Ophiure, Müller's Arch., 1851, p. 338. — Ueber die Larve des Echinus brevispinosus, Müller's Arch., 1853, p. 361. — Beobachtungen über Echinodermenlarven, Müller's Arch., 1854, p. 208. — SCHULTZE, (M.) Ueber die Entwickelung von Ophiolepis squamata, Müller's Arch., 1852, p. 37.

proles medusina,[1] and whether they separate or remain connected, their structural relations are everywhere the same. A comparison of Hydractinia, which is the most common and the most polymorphous Hydroid, with our common Portuguese Man-of-War (Physalia,) may at once show the homology of their most polymorphous individuals.

The embryology of Mollusks has been very extensively investigated, and some types of this branch are among the very best known in the animal kingdom. The natural limits of the branch itself appear, however, somewhat doubtful. I hold that it must include the Bryozoa,[2] which lead gradually through the Brachiopods[3] and Tunicata to the ordinary Acephala, and I would add, that I have satisfied myself of the propriety of uniting the Vorticellidæ with Bryozoa. On the other hand, the Cephalopods can never be separated from the Mollusks proper, as a distinct branch; the partial segmentation of their yolk no more affords a ground for their separation, than the total segmentation of the yolk of Mammalia would justify their separation from the other Vertebrata. Moreover, Cephalopods are in all the details of their structure homologous with the other Mollusks. The Tunicata are particularly interesting, inasmuch as the simple Ascidians have pedunculated young, which exhibit the most striking resemblance to Boltenia, and form, at the same time, a connecting link with the compound Ascidians.[4] The development of the Lamellibranchiata seems to

[1] I shall show this fully in my second volume. Meanwhile, see my paper on the structure and homologies of Radiata, q. a., p. 20.

[2] ALLMAN, (G. J.,) On the Present State of our Knowledge of the Fresh Water Polyzoa, Proc. Brit. Asso. Adv. Sc., 20th Meet., Edinburgh, 1850, p. 305. —Proc. Irish Ac. 1850, vol. 4, p. 470. — Ibid., 1853, vol. 5, p. 11. — VANBENEDEN, (P. J.,) Recherches sur l'Anatomie, la physiologie et le développement des Bryozoaires qui habitent la côte d'Ostende, Nouv. Mém. Ac. Brux., 1845, vol. 18. — DUMORTIER, (B. C.,) et VANBENEDEN, (P. J.,) Histoire naturelle des Polypes composés d'eau douce, Mém. Ac. Brux., 1850, vol. 16, 4to. fig. — HINCKS, (TH.,) Notes on British Zoophites, with Descriptions of some New Species, Ann. and Mag. Nat. Hist., 2d ser., 1851, vol. 8, p. 353. — EHRENBERG, (C. G.,) Die Infusionsthiere als vollkommene Organismen, Leipzig, 1838, 2 vols. fol. fig. — STEIN, (F.,) Infusionsthiere auf ihre Entwickelungsgeschichte untersucht, Leipzig, 1854, 1 vol. 4to. fig. — FRANTZIUS, (AL. V.,) Analecta ad Ophrydii versatilis historiam naturalem, Vratislav, 1849. — LACHMANN, (C. F. J.,) Ueber die Organization der Infusorien, besonders der Vorticellen, Müller's Arch., 1856, p. 340. Having satisfied myself that the Vorticellidæ are Bryozoa, I would also refer here to all the works on Infusoria in which these animals are considered.

[3] I see from a short remark of Leuckart, Zeitsch. f. wiss. Zool., vol. 7, suppl., p. 115, that he has also perceived the close relationship which exists between Brachiopods and Bryozoa.

[4] SAVIGNY, (J. C.,) Mémoires sur les Anim. sans Vertèbres, etc. q. a. — CHAMISSO, (AD. A.,) De animalibus quibusdam e classe Vermium Linnæana, Fasc. 1, De Salpa, Berol, 1819, 4to., fig. — MEYEN, (F. J.,) Beiträge zur Zoologie, etc., 1st Abth., über Salpen, Nov. Act. Nat. Cur. 1832, vol. 16. — EDWARDS, (H. MILNE,) Observations sur les Ascidies composées des côtes de la Manche, Paris, 1841, 4to., fig. — SARS, (M.,) Beskrivelser, q. a. — Fauna litt., q. a. — VANBENEDEN, (P. J.,) Recherches sur

be very uniform, but they differ greatly as to their breeding, many laying their eggs before the germ is formed, whilst others carry them in their gills until the young are entirely formed.[1] This is observed particularly among the Unios, some of which, however, lay their eggs very early, while others carry them for a longer or shorter time, in a special pouch of the outer gill, which presents the most diversified forms in different genera of this family. Nothing is as yet known of the development of Brachiopods. The Gasteropods[2] exhibit a much greater diversity

l'embryogénie, l'anatomie et la physiologie des Ascidies simples, Mém. Ac. Brux., 1847, vol. 20.—KROHN, (A.,) Ueber die Entwickelung der Ascidien, Müller's Arch., 1852, p. 312.—KÖLLIKER, (A.,) et LÖWIG, De la composition et de la structure des enveloppes des Tuniciers, Ann. Sc. Nat. 3e sér., vol. 5, p. 193.—HUXLEY, (TH. H.,) Observations upon the Anatomy and Physiology of Salpa and Pyrosoma, Philos. Trans. R. Soc., 1851, II., p. 567.—ESCHRICHT, (D. F.,) Anatomisk-physiologiske Undersögelser over Salperne, Kiöb. 1840, fig.—STEENSTRUP, (J.,) Ueber den Generationswechsel, q. a.—VOGT, (C.,) Bilder aus dem Thierleben, Frankfurt a. M., 1852, 8vo.—MÜLLER, (H.,) Ueber Salpen, Zeitsch. f., wiss., Zool., vol. 4, p. 329.—LEUCKART, (R.,) Zoologishe Untersuchungen, Giessen, 1853–54, 4to., fig., 2d Fasc.

[1] CARUS, (C. G.,) Entwickelungsgeschichte unserer Flussmuschel, Leipzig, 1832, 4to., fig.—QUATREFAGES, (ARM. DE,) Sur l'embryogénie des Tarets, Ann. Sc. Nat., 3e sér., 1849, vol. 2, p. 202.—Sur la vie interbranchiale des petites Anodontes, Ann. Sc. Nat., 2de sér., vol. 5, p. 321.—LOVEN, (S. L.,) Om Utvecklingen of Mollusca Acephala, Overs. Vet. Akad. Förhandl. Stockholm, 1849.—Germ. Müller's Arch., 1848, p. 531, and Wiegman's Arch., 1849, p. 312.—PREVOST, (J. L.,) De la génération chez la moule des peintres, Mém. Soc. Phys. Genève, 1825, vol. 3, p. 121.—SCHMIDT, (O.,) Ueber die Entwickelung von Cyclas calyculata Drap. Müller's Arch., 1854, p. 428.—LEYDIG, (F.,) Ueber Cyclas cornea, Müller's Arch., 1855, p. 47.

[2] CARUS, (C. G.,) Von den äussern Lebensbedingungen der weiss- und kaltblütigen Thiere, Leipzig, 1824, 4to., fig.—PREVOST, (J. L.,) De la génération chez le Lymnée, Mém. Soc. Phys., Genève, vol. 5, p. 119.—SARS, (M.,) Zur Entwickelungsgeschichte der Mollusken und Zoophyten, Wiegm. Arch., 1837, I., p. 402; 1840, I., p. 196.—Zusätze zu der von mir gegebenen Darstellung der Entwickelung der Nudibranchien. Wiegm. Arch. 1845, I. p. 4.—QUATREFAGES, (ARM. DE,) Mémoire sur l'Embryogénie des Planorbes et des Lymnées, Ann. Sc. Nat., 2de sér., vol. 2, p. 107.—VANBENEDEN, (P. J.,) Recherches sur le développement des Aplysies, Ann. Sc. Nat., 2de sér., vol. 15, p. 123.—VANBENEDEN, (P. J.,) et WINDISCHMAN, (CH.,) Recherches sur l'Embryogénie des Limaces, Mém. Ac. Brux., 1841.—JACQUEMIN, (EM.,) Sur le développement des Planorbes, Ann. Sc. Nat., vol. 5, p. 117; Nov. Act. Nat. Cur., vol. 18.—DUMORTIER, (B. C.,) Mémoire sur les évolutions de l'embryon dans les Mollusques Gastéropodes, Mém. Ac. Brux., 1836, vol. 10.—LAURENT, (J. L. M.,) Observations sur le développement de l'oeuf des Limaces, Ann. Sc. Nat., vol. 4, p. 248.—POUCHET, (F. A.,) Sur le développement de l'embryon des Lymnées, Ann. Sc. Nat., 2de sér., vol. 10, p. 63.—VOGT, (C.,) Recherches sur l'Embryologie de l'Actæon, Ann. Sc. Nat., 3e sér., 1846, vol. 6, p. 5.—Beitrag zur Entwickelungsgeschichte eines Cephalophoren, Zeitsch. f. wiss. Zool., 1855, vol. 7, p. 162.—SCHULTZE, (M.,) Ueber die Entwickelung des Tergipes lacinulatus, Wiegm. Arch., 1849, I., p. 268.—WARNECK, (N. A.,) Ueber die Bildung und Entwickelung des Embryo bei Gasteropoden, Bull. Soc. Imp., Moscou, 1850, vol. 23, I., p. 90.—SCHMIDT, (O.,) Ueber die Entwickelung von Limax agrestis, Müller's Arch., 1851, p. 278.—LEYDIG, (F.,) Ueber Paludina vivipara, ein Beitrag zur nähern Kenntniss dieses Thieres in embryologischer, anatomischer und histologischer Beziehung, Zeitsch.

in their development than the Lamellibranchiata. Even among the terrestrial and aquatic Pulmonata there are striking differences. Some of the Pectinibranchiata are remarkable for the curious cases in which their eggs are hatched and the young developed, to an advanced state of growth. The cases of Pyrula and Strombus are among the most extraordinary of these organic nests. The embryology of Cephalopods[1] has been masterly illustrated by Kölliker.

There is still much diversity of opinion among naturalists, respecting the limits of Articulata; some being inclined to separate the Arthropoda and Worms as dis-

f. wiss. Zool., 1850, vol. 2, p. 125.—KÖLLIKER, (A.,) q. a., Zeitsch. f. wiss. Zool., vol. 4, p. 333 and 369.—MÜLLER, (J.,) Ueber verschiedene Formen von Seethieren, Müller's Arch., 1854, p. 69.—Ueber Synapta digitata und über die Erzeugung von Schnecken in Holothurien, Berlin, 1852, 4to. fig.—The remarkable case described in this paper, admits of an explanation which Müller has not considered. It is known, that fishes penetrate into the cavity of the body of Holothuriæ, through its posterior opening. (DE BOSSET, Notice, etc., Mém. Soc. Sc. Nat., Neuch., 1839, vol. 2, 4to.) The similarity of Entoconcha mirabilis with the embryonic shell of various species of Littorinæ, such as Lacuna vincta, the development of which I had an opportunity of studying, suggests the possibility, that some species of this family, of which there are many very small ones, select the Synapta as their breeding place and leave it after depositing their eggs, which may become connected with the Synapta, as our Mistletoe or the Orobanche and many other parasitic plants, with the plants upon which they grow.—GEGENBAUER, (C.,) Beiträge zur Entwickelungsgeschichte der Landgasteropoden, Zeitsch. f. wiss. Zool., 1852, vol. 3, p. 371.—Untersuchungen über Pteropoden und Heteropoden, Leipzig, 1855, 1 vol., 4to. fig.—KOREN, (J.,) und DANIELSSEN, (D. C.,) Bitrag til Pectinibranchiernes Udviklingshistorie, Bergen, 1851, 8vo.; French Ann. Sc. Nat., 1852, vol. 18, p. 257, and 1853, vol. 19, p. 89; also Germ. in Wiegm. Arch., 1853, p. 173.—NORDMANN, (AL. V.,) Versuch einer Monographie von Tergipes Edwardsii, St. Petersburg, 1844, 4to.—LEUCKART, (R.,) Zoologische Untersuchungen, Giessen, 1853–54, 4to., fig., 3d Fasc.—HUXLEY, (TH. H.,) On the Morphology of the Cephalous Mollusca, etc., Phils. Trans. R. Soc., 1853, I., p. 29.—HOGG, (JABEZ,) On the Development and Growth of the Watersnail, Quart. Micr. Journ., 1854, p. 91.—REID, (J.,) On the Development of the Ova of the Nudibranchiate Mollusca, Ann. and Mag. Nat. Hist., 1846, vol. 17, p. 377.—CARPENTER, (W. B.,) On the Development of the Embryo of Purpura Lapillus, Quart. Micr. Journ., 1845, p. 17.

[1] KÖLLIKER, (ALB.,) Entwickelungsgeschichte der Cephalopoden, Zurich, 1844, 4to., fig.—VAN-BENEDEN, (P. J.,) Recherches sur l'Embryogénie des Sépioles, N. Mém. Acad. Brux., vol. 14, 1841.—COLDSTREAM, (Z.,) On the Ova of Sepia, Lond. and Ed., Phil. Mag., Oct., 1833.—DUGES, (ANT.,) Sur le développement de l'embryon chez les Mollusques Céphalopodes, Ann. Sc. Nat., vol. 8, p. 107.—RATHKE, (H.,) Perothis, ein neues genus der Cephalopoden, Mém. Ac. St. Petersb., 1834, vol. 2, p. 149. (Is the young of some Loligoid Cephalopod.) MILNE-EDWARDS, (H.,) Observations sur les spermatophores des Mollusques Céphalopodes, etc., Ann. Sc., n., 2de sér., vol. 3, p. 193.—KÖLLIKER, (A.,) Hectocotylus Argonautæ Delle Chiaje und Hect. Tremoctopodis K., die Männchen von Argonauta Argo und Tremoctopus violaceus, Ber. Zool. Anst. Würzburg, 1849, p. 69.—MÜLLER, (H.,) Ueber das Männchen von Argonauta Argo und die Hectocotylen, Zeitsch. f. wiss. Zool., vol. 4, p. 1.—VERANY, (J. B.,) et VOGT, (C.,) Mémoire sur les Hectocotyles et les males de quelques Céphalopodes, Ann. Sc. n., 3e sér., 1852, vol. 17, p. 147.—ROULIN, (F. D.,) De la connaissance qu'ont eue les anciens du bras copulateur chez certains Céphalopodes, Ann. Sc. n., 3e sér., 1852, vol. 17, p. 188.—LEUCKART, (R.,) Zool. Unters. q. a.

tinct branches, while others unite them into one. I confess I cannot see the ground for a distinction. The worm-like nature of the larvæ of the majority of Arthropods and the perfect homology of these larvæ with the true Worms, seem to me to show beyond the possibility of a doubt, that all these animals are built upon one and the same plan, and belong, therefore, to one branch, which contains only three classes, if the principles laid down in my second chapter are at all correct, namely, the Worms, Crustacea, and Insects. As to the Protozoa, I have little confidence in the views generally entertained respecting their nature. Having satisfied myself that Colpoda and Paramecium are the brood of Planariæ, and Opalina that of Distoma, I see no reason, why the other Infusoria, included in Ehrenberg's division Enterodela,[1] should not also be the brood of the many lower Worms, the development of which has thus far escaped our attention. Again, a comparison of the early stages of development of the Entomostraca with Rotifera might be sufficient to show, what Burmeister, Dana, and Leydig have proved in another way, that Rotifera are genuine Crustacea, and not Worms. The vegetable character of most of the Anentera has been satisfactorily illustrated. I have not yet been able to arrive at a definite result respecting the Rhizopods, though they may represent, in the type of Mollusks, the stage of yolk segmentation of Gasteropods. From these remarks it should be inferred, that I do not consider the Protozoa as a distinct branch of the animal kingdom, nor the Infusoria as a natural class.[2]

Taking the class of Worms, in the widest sense, it would thus embrace the

[1] That Vorticellidæ are Bryozoa, has already been stated above.

[2] SCHULTZE, (M.,) Beiträge zur Naturgeschichte den Turbellarien, Greifswald, 1851, 4to., fig. — Zoologische Skizzen, Zeitsch. f. wiss. Zool. 1852, vol. 4, p. 178. — MÜLLER, (J.,) Ueber eine eigenthümliche Wurmlarve, etc., Archiv, 1850, p. 485. — DESOR, (E.,) On the Embryology of Nemertes, with an Appendix on the Embryonic Development of Polynoe, Boston Journ. Nat. Hist. 1850, vol. 6, p. 1; Müller's Archiv, 1848, p. 511. — AGASSIZ, (L.,) Colpoda and Paramecium are larvæ of Planariæ, Proc. Am. Ass. Adv. Sc., Cambridge, 1849, p. 439. — GIRARD, (CH.,) Embryonic Development of Planocera elliptica, Jour. Ac. Nat. Sc. Phil., 2d ser. 1854, vol. 2, p. 307. — EHRENBERG, (C. G.,) Die Infusionsthierchen, etc., q. a. — KÜTZING, (F. T.,) Ueber die Verwandlung der Infusorien in niedere Algenformen, Nordhausen, 1844, 4to. fig. — SIEBOLD, (C. TH. E. v.,) Ueber einzellige Pflanzen und Thiere, Zeitsch. f. wiss. Zool. 1849, vol. 1, p. 270. — NAEGELI, (C.,) Gattungen einzelliger Algen, Zurich, 1849, 4to. fig. — BRAUN, (A.,) Algarum unicellularium genera nova et minus cognita, Leipzig, 1855, 4to. fig. — COHN, (F.,) Beiträge zur Entwickelungsgeschichte der Infusorien Zeitsch. f. wiss. Zool. 1851, vol. 3, p. 257. — Beiträge zur Kenntniss der Infusorien, Zeitsch. f. wiss. Zool. 1854, vol. 5, p. 420. — Ueber Encystirung von Amphileptus fasciola, ibid. p. 434.—SCHULTZE, (M.,) Ueber den Organismus der Polythalamien, Leipzig, 1854, 1 vol. fol. fig. — Beobachtungen über die Fortpflanzung der Polythalamien, Müller's Archiv, 1856, p. 165. — AUERBACH, (L.,) Ueber die Einzelligkeit der Amoeben Zeitsch. f. wiss. Zool. 1855, vol. 7, p. 365. — Ueber Encystirung von Oxytricha Pellionella, Zeitsch. f. wiss. Zool. 1854, vol. 5, p. 430. — CIENKOWSKY, Ueber Cystenbildung bei Infusorien, Zeitsch. f. wiss. Zool. 1855, vol. 6, p. 301.

Helminths, Turbellariæ, and Annulata. The embryology of these animals still requires careful study, notwithstanding the many extensive investigations to which they have been submitted; the intestinal Worms especially continue to baffle the zeal of naturalists, even now when the leading features of their development are ascertained. The Nematoids undergo a very simple development, without alternate generations, and as some are viviparous their changes can easily be traced.[1] The Cestods and Cystici, which were long considered as separate orders of Helminths, are now known to stand in direct genetic connection with one another, the Cystici being only earlier stages of development of the Cestods.[2] The Trematods exhibit the most complicated phenomena of alternate generations; but as no single species has thus far been traced through all the successive stages of its transformations, doubts are

[1] STEIN, (F.,) Beiträge zur Entwickelungsgeschichte der Eingeweidewürmer, Zeitsch. f. wiss. Zool., 1852, vol. 4, p. 196.—NELSON, (H.,) On the Reproduction of the Ascaris Mystax, Philos. Trans. R. Soc., 1852, II., p. 563.—GRUBE, (E.,) Ueber einige Anguillulen und die Entwickelung von Gordius aquaticus, Wiegmann's Archiv, 1849, I., p. 358.—SIEBOLD, (C. TH. E. v.,) Ueber die Wanderung der Gordiaceen, Uebers. d. Arb. und Ver. schles. Ges. f. vaterl. Kultur., 1850, p. 38.—MEISSNER, (G.,) Beiträge zur Anatomie und Physiologie von Mermis albicans, Zeitsch. f. wiss. Zool., 1853, vol. 5, p. 207.—Beobachtungen über das Eindringen der Saamenelemente in den Dotter, Zeitsch. f. wiss. Zool., 1855, vol. 6, p. 208, und 272.—Beiträge zur Anatomie und Physiologie der Gordiaceen, Zeitsch. f. wiss. Zool., 1855, vol. 7, p. 1.—KÖLLIKER, (A.,) Beiträge zur Entwickelungsgeschichte wirbelloser Thiere, Müller's Archiv, 1843, p. 68.—BAGGE, (H.,) Dissertatio inaug. de evolutione Strongyli auricularis et Ascaridis acuminatæ, Erlangen, 1841, 4to. fig.—LEIDY, (JOS.,) A Flora and Fauna within living Animals, Smithson. Contrib. 1853, 4to. fig.—LUSCHKA, (H.,) Zur Naturgeschichte der Trichina spiralis, Zeitsch. f. wiss. Zool. 1851, vol. 3, p. 69.—BISCHOFF, (TH.,) Ueber Ei- und Samenbildung und Befruchtung bei Ascaris Mystax, Zeitsch. f. wiss. Zool., 1855, vol. 6, p. 377.—Widerlegung, des von DR. KEBER bei den Najaden und DR. NELSON bei den Ascariden behaupteten Eindringens der Spermatozoiden in das Ei, Giessen, 1854, 4to. fig.—Bestätigung des von DR. NEWPORT bei den Batrachiern und DR. BARRY bei den Kaninchen behaupteten Eindringens der Spermatozoiden in das Ei, Giessen, 1854, 4to.

[2] VAN BENEDEN, (P. J.,) Les Helminthes Cestoides, etc., Bullet. Ac. Belg., vol. 16, et seq.; Mém. Ac. Brux., 1850, vol. 17, et seq.—KÖLLIKER, (A.,) Beiträge, etc., q. a.; p. 81.—SIEBOLD, (C. TH. E. v.,) Ueber den Generationswechsel der Cestoden, etc., Zeitsch. wiss. Zool., 1850, vol. 2, p. 198.—Ueber die Umwandlung von Blasenwürmer in Bandwürmer, Uebers. d. Arb. und Ver. d. schles. Ges. f. vaterl. Kultur, 1852, p. 48.—Ueber die Verwandlung des Cysticercus pisiformis in Tænia serrata, Zeitsch. f. wiss. Zool., 1853, vol. 4, p. 400.—Ueber die Verwandlung der Echinococcus-Brut in Tænien, Ibid., 1853, p. 409.—Ueber die Band-und Blasenwürmer, nebst einer Einleitung über die Entstehung der Eingeweidewürmer, Leipzig, 1854, 8vo. fig.—HUXLEY, (TH. H.,) On the Anatomy and Development of Echinococcus veterinorum, Ann. and Mag. Nat. Hist. 2d ser., vol. 14, p. 379.—KÜCHENMEISTER, (FR.,) Ueber die Umwandlung der Finnen (Cysticerci) in Bandwürmer (Tæniæ) Prag. Vierteljahrssch, 1852, p. 106.—WAGENER, (R. G.,) Die Entwickelung der Cestoden, Bonn, 1855, 1 vol. 4to. fig.—MEISSNER, (G.) Zur Entwickelungsgeschichte und Anatomie der Bandwürmer, Zeitsch. f. wiss. Zool., 1854, vol. 5, p. 380.—LEUCKART, (R.,) Erziehung des Cysticercus fasciolaris aus den Eiern der Tænia crassicollis, Zeitsch. f. wiss. Zool. 1854, vol. 6, p. 139.

still entertained respecting the genetic connection of many of the forms which appear to belong to the same organic cycle.[1] It is also still questionable, whether Gregarinæ and Psorospermia are embryonic forms or not, though the most recent investigations render it probable that they are.[2] The development of the Annulata, as they are now circumscribed, exhibits great variety;[3] some resemble more the Nematods, in their metamorphoses, while others, the Leeches for instance,

[1] NORDMANN, (AL. v.,) Micrographische Beiträge zur Naturgeschichte der wirbellosen Thiere, Berlin, 1832, 4to. fig. — BOJANUS, (L.,) Zerkarien und ihr Fundort, Isis 1818, vol. 4, p. 729. — Enthelmintica Isis 1821, p. 162. — CARUS, Beobachtungen über einen merkwürdigen Eingeweidewurm, Leucochloridium paradoxum, Nov. Act. Ac. Nat. Cur., vol. 17, p. 85. — SIEBOLD, (C. TH. E. v.,) Helminthologische Beiträge, Wiegman's Archiv, 1835, vol. 1, p. 45. — Ueber die Conjugation des Diplozoon paradoxum, etc., Zeitsch. f. wiss., Zool., 1851, vol. 3, p. 62. — Gyrodactylus, ein ammendes Wesen. Zeitsch. f. wiss. Zool., 1849, vol. 1, p. 347. — STEENSTRUP, (J.,) Generationswechsel, etc., q. a. — BILHARZ, (TH.,) Ein Beiträg zur Helminthographia humana, Zeitsch. f. wiss. Zool., 1852, vol. 4, p. 59. — AGASSIZ, (L.,) Zoölogical Notes, etc., Amer. Journ. Sc. and A. 1852, vol. 13, p. 425. — BAER, (K. E. v.,) Beiträge zur Kenntniss der niedern Thiere, Act. Nov. Nat. Cur. 1827, vol. 13. — AUBERT, (H.,) Ueber das Wassergefässsystem, die Geschlechtsverhältnisse, die Eibildung und die Entwickelung von Aspidogaster conchicola, Zeitsch. f. wiss. Zool. 1855, vol. 6, p. 349. — LEIDY, (JOS.,) Description of two new Species of Distoma, with the partial History of one of them, Jour. Ac. Nat. Sc. Phil. 1850, vol. 1, p. 301, fig.

[2] MÜLLER, (J.,) Ueber eine eigenthümliche krankhafte parasitische Bildung, etc., Müller's Archiv, 1841, p. 477. — Ueber parasitische Bildungen etc., Müller's Archiv, 1842, p. 193. — DUFOUR, (L.,) Note sur la Grégarine, etc., Ann. Sc. Nat., 1828, vol. 13, p. 366, fig. — Ibid., 2de sér., 1837, vol. 7, p. 10. — SIEBOLD, (C. TH. E. v.,) Beiträge etc., q. a.; p. 56–71. — HAMMERSCHMIDT, (C. ED.,) Helminthologische Beiträge, Isis 1838, p. 351. — KÖLLIKER, (A.,) Die Lehre von der thierischen Zelle, etc., Zeitsch. wiss. Botanik. 1845, vol. i., p. 46, and p. 97. — Beiträge zur Kenntniss niederer Thiere, Zeitsch. f. wiss. Zool. 1848, vol. i. p. 1. — HENLE, (J.,) Ueber die Gattung Gregarina, Müller's Archiv, 1845, p. 369. — FRANTZIUS, (AL. v.,) Observationes quædam de Gregarinis, Berolini, 1846. — STEIN, (F.,) Ueber die Natur der Gregarinen, Müller's Archiv, 1848, p. 182, fig. — BRUCH, (C.,) Einige Bemerkungen über die Gregarinen, Zeitsch. f. wiss. Zool. 1850, vol. 2, p. 110. — LEYDIG, (F.,) Ueber Prorospermien und Gregarinen, Müller's Archiv, 1851, p. 221. — LEIDY, (JOS.,) On the Organization of the Genus Gregarina, Trans. Amer. Phil. Soc. 1851, vol. 10, p. 233. — Some Observations on Nematoidea imperfecta and Descriptions of three parasitic Infusoria, Trans. Amer. Phil. Soc. 1851, vol. 10, p. 241. — LIEBERKÜHN, (N.,) Ueber die Psorospermien, Müller's Archiv, 1854, p. 1.

[3] WEBER, (E. H.,) Ueber die Entwickelung von Hirudo medicinalis, Meckel's Archiv, 1828, p. 366, fig. — FILIPPI, (FIL. DE,) Sopra l'anatomia e lo sviluppo delle Clepsine, Pavia, 1839, 8vo. fig. — LOVEN, (J.,) Beobachtungen über die Metamorphose einer Annelide, K. Vet. Ac. Handl. 1840, Wiegmann's Archiv, 1842, vol. i., p. 302. — OERSTED, (A. S.,) Ueber die Entwickelung der Jungen bei einer Annelide, etc., Wiegmann's Archiv, 1845, vol. i., p. 20. — SARS, (M.,) Zur Entwickelung der Anneliden, Wiegmann's Archiv, 1845, vol. i., p. 11. — MENGE, (A.,) Zur Roth-Würmer Gattung Euaxes, Wiegmann's Archiv, 1845, vol. i., p. 24. — GRUBE, (A. E.,) Zur Anatomie und Entwickelung der Kiemenwürmer, Königsberg, 1838, 4to. — Actinien, Echinodermen und Würmer, etc., Königsberg, 1840, 4to. fig. — Untersuchungen über die Entwickelung der Clepsine, Dorpat, 1844. — EDWARDS, (H. MILNE,) Observations sur le développement des Annélides, Ann. Sc. Nat. 3e sér. 1845, vol. 3, p. 145. — KOCH, (H.,) Einige

approximate more the type of the Trematods. The Sipunculoids appear to be more closely related to the Annulata than to the Holothurioids.[1]

The class of Crustacea, on the contrary, may be considered as one of the best known, as far as its zoölogical characters and embryonic growth are concerned; the only point still questioned being the relationship of the Rotifera.[2] In their mode of development the Lernæans, the Entomostraca proper, and the Cirripeds agree as closely with one another as they differ from the higher Crustacea. This conformity[3] is the more interesting, as the low position the Entomostraca hold in the

Worte zur Entwickelungsgeschichte der Eunice, mit einem Nachworte von Kölliker, N. Denksch. Schw. Gesell., 1847, vol. 8, 4to. fig. — QUATREFAGES, (A. DE,) Mémoire sur l'Embryogénie des Annélides, Ann. Sc. Nat. 3e sér., 1848, vol. 10, p. 153, fig. — DESOR, (ED.,) On the Embryology, etc., q. a. — LEIDY, (JOS.,) Descriptions of some American Annelida abranchia, Journ. Ac. Nat. Sc. Phil. 1850, vol. 2, p. 43, fig., (Lumbricillus contained several thousand large Leucophrys. The case related here by Leidy seems to me to indicate rather the hatching of Opalinas from the eggs of Lumbricillus, than the presence of parasitic Leucophrys.) — SCHULTZE, (M.,) Ueber die Fortpflanzung durch Theilung bei Nais proboscidea, Wiegman's Archiv, 1849, I., p. 293; id. 1852, I., p. 3. — Zoologische Skizzen (Arenicola piscat.) Zeitsch. f. wiss. Zool. 1852, vol. 4, p. 192. — BUSCH, (W.,) Beob. über Anat. und Entw. q. a. (p. 55.) — MÜLLER, (M.,) Observationes anatomicæ de Vermibus quibusdam maritimis, Berolini, 1852, 4to.; Müller's Archiv, 1852, p. 323. — Ueber die weitere Entwickelung von Mesotrocha sexoculata, Müller's Archiv, 1855, p. 1.—Ueber Sacconereis helgolandica, Müller's Archiv, 1855, p. 13. — KROHN, (A.,) Ueber die Erscheinungen bei der Fortpflanzung von Syllis, Wiegman's Archiv, 1852, I., p. 66. — Ueber die Sprösslinge von Autolytus prolifer Gr., Müller's Archiv, 1855, p. 489. — LEUCKART, (R.,) Ueber die ungeschlechtliche Vermehrung bei Nais proboscidea, Wiegman's Archiv, 1851, p. 134. — Ueber die Jugendzustände einiger Anneliden, Wiegman's Archiv, 1855, I., p. 63.

[1] PETERS, (W.) Ueber die Fortpflanzungsorgane des Sipunculus, Müller's Archiv, 1850, p. 382. — MÜLLER, (M.,) Ueber eine den Sipunculiden verwandte Wurmlarve, Müller's Archiv, 1850, p. 439. — KROHN, (A.,) Ueber die Larve des Sipunculus nudus, etc., Müller's Archiv, 1851, p. 368. — SCHMARDA, (L.,) Zur Naturgeschichte der Adria (Bonellia viridis) Denksch. Wien. Akad. 1852, vol. 4, p. 117, fig. — GEGENBAUER, (C.,) Ueber die Entwickelung von Doliolum, der Scheibenquallen und von Sagitta, Zeitsch. f. wiss. Zool. vol. 5, p. 13.

[2] EHRENBERG, (C. J.) Die Infusionsthierchen, etc., q. a. — DALRYMPLE, (J.,) Description of an Infusory Animalcule allied to the Genus Notommata. Philos. Trans. 1844, II., p. 331. — NAEGELI, (H.,) Beiträge zur Entwickelungsgeschichte der Räderthiere, inaug. Diss., Zurich, 1852, 8vo. fig. — LEYDIG, (FR.,) Ueber den Bau und die systematische Stellung der Räderthiere, Zeitsch. f. wiss. Zool. 1854, vol. 6, p. 1. — Zur Anatomie und Entwickelungsgeschichte der Lacinularia socialis, Zeitsch. f. wiss. Zool. 1852, vol. 3, p. 452. — COHN, (F.,) Ueber die Fortpflanzung der Räderthiere, Zeitsch. f. wiss. Zool., 1855, vol. 7, p. 431. — HUXLEY, (TH. H.,) Lacinularia socialis, Trans. M. Soc., Micr. Journ. 1852, p. 12. — WILLIAMSON, (W. C.,) On the Anatomy of Melicerta ringens. Quart. Micr. Journ. 1852, p. 1.

[3] JURINE, (L.,) Histoire des Monocles qui se trouvent aux environs de Genève, Paris, 1806, 4to. fig. — EDWARDS, (H. MILNE,) in Cuvier, Règn. An. édit. illustr. q. a. Crustacés; represents young Limulus. — ZADDACH, (E. G.,) De Apodis cancriformis Anatome et Historia evolutionis Bonnæ, 1841, 4to. fig. — NORDMANN, (AL. V.,) Micrógr. Beitr. q. a. — LEYDIG, (FR.,) Ueber Argulus foliaceus, ein Beitrag zur Anatomie, Histologie und Entwickelungsgeschichte dieses Thieres, Zeitsch. f. wiss. Zool. 1850, vol. 2, p. 323. — Ueber Artemia salina und Branchi-

class of Crustacea, agrees strikingly with their early appearance in geological times, while the form of the adult Cirripeds[1] and that of the Lernæans would hardly lead one to suspect their near relationship, which has, indeed, been quite overlooked until Embryology showed that their true position is among Crustacea. In the development of the higher Crustacea,[2] their superior rank is plainly exhibited, and few types show more directly a resemblance, in their early stages of development, to the lower members of their class, than the Brachyura.

In the class of Insects, I include Myriapods, Arachnoids, and the true Insects, as, according to the views expressed hereafter, these natural groups constitute only different degrees of complication of the same combination of organic systems, and must, therefore, be considered as natural orders of one and the same class. This class, though very extensively studied in a zoölogical and anatomical point of view, and as far as the habits of its representatives are concerned, still requires, however, much patient work, as the early embryonic development of these animals has been much less studied than their later transformations.[3] The type of the Arachnoids

pus stagnalis, Zeitsch. f. wiss. Zool. 1851, vol. 3, p. 280.—VANBENEDEN, (P. J.,) Recherches sur quelques Crustacés inférieurs Ann. Sc. Nat. 3e sér. 1851, vol. 16, p. 71.—Mémoire sur le développement et l'organisation des Nicothoés, Ann. Sc. Nat. 3e sér. 1850, vol. 13, p. 354.—BARRANDE, (J.,) Syst. sil. q. a.; contains the first observations upon the transformations of Trilobites.

[1] THOMPSON, (W. V.,) Zoölogical Researches and Illustrations, or Natural History of nondescript or imperfectly known Animals, Cork, 1828–34, 8vo., fig.—BURMEISTER, (H.,) Beiträge zur Naturgeschichte der Rankenfüsser, (Cirripedia,) Berlin, 1834, 1 vol. 4to. fig.—GOODSIR, (H. D. S.,) On the Sexes, Organs of Reproduction, and Development of Cirripeds, Ed. N. Phil. J. 1843, No. 35, p. 88, fig.—MARTIN ST. ANGE, (G. J.,) Mémoire sur l'organisation des Cirripèdes et sur leurs rapports naturels avec les animaux articulés, Ann. Sc. Nat. 1831, p. 366, fig.—DARWIN, (CH.,) A Monograph of the sub-class Cirripedia, with Figures of all the Species, London, 1851, 2 vols. 8vo. (Ray Society.)—BATE, (SPENCE,) On the Development of the Cirripedia, Ann. and Mag. Nat. Hist. 2d ser. vol. 8, p. 324.

[2] RATHKE, (H.,) Untersuchungen über die Bildung und Entwickelung des Flusskrebses, Leipzig, 1829, 1 vol. fol. fig.—Beiträge zur Fauna Norvegica, Act. Nov. Ac. Leop. Cæs. vol. 20.—Beiträge zur vergleichenden Anatomie und Physiologie, Reisebemerkungen aus Skandinavien, Dantzig, 1842, 4to.—Zur Morphologie, Reisebemerkungen aus Taurien, Riga und Leipzig, 1837, 4to. fig.—Ueber die Entwickelung der Decapoden, Müller's Archiv, 1836, p. 187, Wiegman's Archiv, 1840, I., p. 241.—Beobachtungen und Betrachtungen über die Entwickelung der Mysis vulgaris, Wiegman's Archiv, 1839, p. 195, fig.—ERDL, (M. P.,) Entwickelung des Hummereies, München, 1843, 4to. fig.—EDWARDS, (H. MILNE,) sur la génération des Crustacés, Ann. Sc. Nat. 1829.—Observations sur les changements de forme que divers Crustacés éprouvent dans le jeune âge, Ann. Sc. Nat. 2de sér. vol. 3, p. 321.—AGASSIZ, (L.,) Zoölogical Notes, etc., Am. Jour. Sc. and A., 1852, p. 426.—Recent Researches, etc., Am. Journ. Sc. and A., 1852, vol. 16, p. 136.

[3] HEROLD, (M.,) Entwickelungsgeschichte der Schmetterlinge, etc., Kassel und Marburg, 1815, 4to. fig.—Disquisitiones de animalium vertebris carentium in ovo formatione, Frankfurt a. M., 1835, fol. fig.—RATHKE, (H.,) Entwickelungsgeschichte der Blatta germanica, Meckel's Archiv, 1832.—Zur Entwickelungsgeschichte der Maulwurfsgrille (Gryl-

embraces two groups, the Acari and the Arachnoids proper, corresponding respectively in this class to the Entomostraca and the higher Crustacea. The embryo of the Acari resembles somewhat that of the Entomostraca, whilst that of the true Spiders[1] recalls the metamorphosis of the higher Crustacea. On the ground of the similarity of their young, some animals, formerly referred to the class of Worms,[2] are now considered as Arachnoids; but the limits between the aquatic Mites and the Pycnogonums are not yet quite defined.

In the branch of Vertebrata, all classes have been extensively studied, and as far as the principal types are concerned, the leading features of their development are satisfactorily known. Much, however, remains to be done to ascertain the minor modifications characteristic of the different families. It may even be, that further investigations will greatly modify the general classification of the whole branch. The class of Fishes[3] may require subdivision, since the development of the Plagios-

lotalpa vulgaris,) Müller's Archiv, 1844, p. 27. — KÖLLIKER, (A.,) Observationes de prima Insectorum Genesi, Turici, 1842, 4to. fig. — ZADDACH, (G.,) Die Entwickelung des Phryganiden Eies, Berlin, 1 vol. 4to. 1854. — LEUCKARDT, (R.,) Ueber die Micropyle und den feinern Bau der Schalenhaut bei den Insekteneiern, Müller's Arch., 1855, p. 90. — NEWPORT, (GEO.,) On the Organs of Reproduction and the Development of Myriapoda, Phil. Trans. R. Soc., 1842, II. p. 99. — STEIN, (FR.,) Vergeichende Anatomie und Physiologie der Insecten, 1ste Monogr., Die weiblichen Geschlechtsorgane der Käfer, Berlin, 1847, fol. fig. — SIEBOLD, (C. TH. E. v.,) Ueber die Fortpflanzung von Psyche, Zeitsch. f. wiss. Zool., 1848, vol. 1, p. 93. — LEYDIG, (FR.,) Einige Remerkungen über die Entwickelung der Blattläuse, Zeitsch. f. wiss. Zool., 1850, vol. 2, p. 62. — MEYER, (H.,) Ueber die Entwickelung des Fettkörpers, der Tracheen und der keimbereitenden Geschechtstheile bei den Lepidopteren, Zeitsch. f. wiss. Zool., 1849, vol. 1. — BURNETT, (W. J.,) Researches on the Development of viviparous Aphides, Amer. Journ. Sci. and Arts, 1854, vol. 17, p. 62 and 261. — As far as the metamorphoses of Insects, after the eclosion of the larva, are concerned, I must refer to the works of Reaumer and Roesel already quoted, and to almost every modern book upon Entomology. The metamorphoses of North American Insects are minutely described in Harris's Report, q. a.

[1] HEROLD, (M.,) De generatione Aranearum in ovo, Marburgi, 1824, fol. fig. — RATHKE, (H.,) Ueber die Entwickelung des Scorpions; Zur Morphologie, q. a. — VANBENEDEN, (P. J.,) Recherches sur l'Histoire naturelle et le développement de l'Atax ypsilophora, Mém. Ac. Brux., 1850, vol. 24, p. 444. — WITTICH, (W. H. v.,) Observationes quædam de aranearum ex ovo evolutione, Diss. inaug. Halis Sax., 1845. — Die Entstehung des Arachnideneies im Eierstock, Müller's Arch., 1849, p. 113. — CARUS, (J. V.,) Ueber die Entwickelung des Spinneneies, Zeitsch. f. wiss. Zool., 1850, vol. 2, p. 97. — DUJARDIN, (F.,) Mémoire sur des Acariens sans bouches, dont on a fait le genre Hypopus et qui sont le premier âge des Gamaoses, Ann. Sc. Nat., 1849, vol. 12, p. 243 et 259.

[2] KAUFMANN, (JOS.,) Ueber die Entwickelung und zoologische Stellung der Tardigraden, Zeitsch. f. wiss. Zool. 1851, vol. 3, p. 220. — VANBENEDEN, (P. J.,) Recherches sur l'organisation et le développement des Linguatules (Pentastoma,) Mém. Ac. Brux. vol. 15, I., p. 188. — SCHUBERT, (T. D.,) Ueber Entwickelung von Pentastomum tænioides Zeitsch. f. wiss. Zool. 1852, vol. 4, p. 117. — WILSON, (E.,) Researches into the Structure and Development of a newly discovered Parasitic Animalcule of the Human Skin, Phil. Trans. R. Soc. 1844, p. 305.

[3] FORCHHAMMER, (G.,) De Blennii vivipari

toms differs greatly from that of the ordinary fishes. As it now stands in our systems, the class of Fishes is certainly the most heterogeneous among Vertebrata.

formatione et evolutione observationes, Kiel, 1819, 4to. — Prevost, (J. L.,) De la génération chez le Séchot (Cottus Gobio), Mém. Soc. Phys. et Hist. Nat., Genève, vol. 4, 1828, 4to. — Rathke, (H.,) Beiträge zur Geschichte der Thierwelt, Halle, 1820–27, 4 vols. 4to. fig. — Abhandlungen zur Bildungs- und Entwickelungsgeschichte des Menschen und der Thiere. Leipzig, 1832-33, 2 vols. 4to. fig. — Ueber das Ei einiger Lachsarten, Meckel's Archiv, 1832, p. 392.— Baer, (K. E. v.,) Untersuchungen über die Entwickelungsgeschichte der Fische, Leipzig, 1835, 4to. — Also Entw. der Thiere, q. a., vol. 2d. — Davy, (J.,) On the Development of the Torpedo, Philos. Trans. R. Soc., 1834. — Filippi, (Fil. de,) Memoria sullo sviluppo del Gobius fluviatilis, Anna. Medic., Milano, 1841, 8vo. fig. — Rusconi, (M.,) Sopra la fecondatione artificiale nei pesci, Giorn. delle Sc. Med.-chir., Pavia, vol. 9; tranls. in Müller's Archiv, 1840, p. 185. — Lettre sur les changements que les œufs de Poissons éprouvent avant qu'ils aient pris la forme d'embryon, Ann. Sc. Nat., 2de sér. vol. 5; transl. Mag. Zool. and Bot., I., p. 586. — Agassiz, (L.,) Histoire naturelle des Poissons d'eau douce de l'Europe centrale, vol. 1. Embryologie des Salmones, par C. Vogt, Neuchâtel, 1842, 8vo. atlas fol. These investigations were made under my direction and supervision. — Müller, (J.,) Ueber den glatten Hai des Aristoteles, und über die Verschiedenheiten unter den Haifishen und Rochen in der Entwickelung des Eies, Berlin, 1842, fol. fig. — Leuckart, (F. S.,) Untersuchungen über die äussern Kiemen der Embryonen von Rochen und Haien, Stuttgardt, 1836, 8vo. fig. — Leydig, (Fr.,) Beiträge zur microscopischen Anatomie und Entwickelungsgeschichte der Rochen und Haie, Leipzig, 1852, 1 vol. 8vo. fig. — Carus, (C. G.,) Erläuterungstafeln, etc., No. 3, Leipzig, 1831, fol. fig. — Shaw, (J.,) Account of some Experiments and Observations on the Parr, etc., Edinb. New Phil. Journ., vol. 21, p. 99. — On the Development and Growth of the Fry of the Salmon, etc., Ibid. vol. 24, p. 165; also Ann. Nat. Hist., I. p. 75, and IV. p. 352. — Yarrell, (W.,) Growth of the Salmon in Fresh Water, Ann. and Mag. Nat. Hist., IV. p. 334. — Duvernoy, (G. L.,) Observations pour servir à la connaissance du développement de la Pécilie de Surinam, An. Sc. Nat., 1844, 3e sér. I. p. 313, fig. — Coste, (P.,) Histoire générale et particulière du développement des corps organisés, Paris, 1847–53, 4to., Atl. fol., 2d Fasc., Epinoche. — Quatrefages, (Arm. de,) Mémoire sur les Embryons des Syngnathes, Ann. Sc. Nat., 2de sér. vol. 18, p. 193, fig. — Sur le développement embryonaire des Blennies, etc., Comptes-Rendus, vol. 17, p. 320. — Valenciennes, (A.,) Anableps in Cuvier et Valenciennes, Histoire naturelle des Poissons, Paris, 1846, vol. 18, p. 245. — Wyman, (J.,) Observations on the Development of Anableps Gronovii, Journ. Bost. Nat. Hist., 1854, vol. 6, fig. — Agassiz, (L.,) Extraordinary Fishes from California, constituting a new family, Amer. Journ. Sc. and A., 1853, vol. 16, p. 380. — Embryology of Lophius americanus, Proc. Am. Ac. 1855. — Lereboullet, (A.,) Recherches sur l'Anatomie des organes génitaux des animaux Vertébrés, N. Act. Ac. Nat. Cur., vol. 23, p. 1. — Ann. Sc. Nat., 4e sér. vol. 1. — Aubert, (H.,) Beiträge zur Entwickelungsgeschichte der Fische, Zeitsch. f. wiss. Zool., 1853, vol. 5, p. 94; 1855, vol. 7. — Valentin, (G.,) Zur Entwickelungsgeschichte der Fische, Zeitsch. f. wiss. Zool., 1850, vol. 2, p. 267. — Leuckart, (R.,) Ueber die allmählige Bildung der Körpergestalt bei den Rochen, Zeitsch. f. wiss. Zool., 1850, vol. 2, p. 258. — Haeckel, (E.,) Ueber die Eier der Scomberesoces, Müller's Arch., 1855, p. 23. — Retzius, (A.,) Ueber den grossen Fetttropfen in den Eiern der Fische, Müller's Arch., 1855, p. 34. — Bruch, (C.,) Ueber die Micropyle der Fische, Zeitsch. f. wiss. Zool., 1855, vol. 7, p. 172. — Reichert, (K. B.,) Ueber die Micropyle der Fischeier, etc., Müller's Arch., 1856, p. 83. — Dowler, (B.,) Discovery of a Viviparous Fish in Louisiana, Amer. Jour. Sc. and Arts, 1855, vol. 19, p. 133, with Remarks by L. Agassiz, p. 136.—Schultze, (M.,) Note sur le développement des Pétromyzons, Comptes-Rendus, 1856, p. 336; Ann. and Mag. Nat. Hist., 2d ser.

The disagreement of authors as to the limits and respective value of its orders and families may be partly owing to the unnatural circumscription of the class itself.[1] As to the Reptiles, it is already certain, that the Amphibia and Reptiles proper, so long united as one class, constitute two distinct classes. In the main, the development of the true Reptiles[2] agrees very closely with that of the Birds, while the Amphibians[3] resemble more the true fishes. In no class are renewed embryological

1856, vol. 17, p. 443.—MÜLLER, (A.,) Ueber die Entwickelung der Neunaugen, Müller's Arch., 1856, p. 303. The unexpected facts mentioned here, render it highly probable, that Amphioxus is the immature state of some marine Cyclostom.

[1] The peculiarities of the development of the Plagiostoms consist not so much in the few large eggs they produce, and the more intimate connection which the embryo of some of them assumes with the parent, than in the development itself, which, notwithstanding the absence of an amnios and an allantois, resembles closely, in its early stages, that of the Reptiles proper and of the Birds, especially in the formation of the vascular system, the presence of a sinus terminalis, etc. Again, besides the more obvious anatomical differences existing between the Plagiostoms and the bony Fishes, it should be remembered that, as in the higher Vertebrata, the ovary is separated from the oviducts in the Sharks and Skates, and the eggs are taken up by a wide fallopian tube. That the Plagiostoms can hardly be considered simply as an order in the class of Fishes, could already be inferred from the fact, that they do not constitute a natural series with the other Fishes. I would, therefore, propose the name of SELACHIANS for a distinct class embracing the Sharks, Skates, and Chimæras. Recent investigations upon the Cyclostoms, show them also to differ widely from the Fishes proper, and they too ought to be separated as a distinct class, for which the name of MYZONTES may be most appropriate.

[2] VOLKMANN, (G. W.) De Colubri Natricis Generatione, Lipsiæ, 1834, 4to.—RATHKE, (H.,) Entwickelungsgeschichte der Natter, (Coluber Natrix,) Königsberg, 1839, 4to. fig.—WEINLAND, (D.,) Ueber den Eizahn der Ringelnatter, Würt. Nat. Hist. Jahreshefte, 1855.—TIEDEMANN, (F.,) Ueber das Ei und den Fœtus der Schildkröte, Heidelberg, 1828, 4to. fig.—BAER, (K. E. v.,) Beiträge zur Entwickelungsgeschichte der Schildkröten, Müller's Archiv, 1834, p. 544.—RATHKE, (H.,) Ueber die Entwickelung der Schildkröten, Braunschweig, 1848, 4to. fig.

[3] RÖSEL v. ROSENHOF, (A. J.,) Historia naturalis Ranarum nostratium, etc., Norimb., 1758, fol. fig.—FUNK, (A. F.,) De Salamandræ terrestris vita, evolutione, formatione, etc., Berlin, 1826, fol. fig.—RATHKE, (H.,) Diss. de Salamandrarum corporibus adiposis eorumque evolutione, Berol. 1818.—Ueber die Entstehung und Entwickelung der Geschlechtstheile bei den Urodelen, N. Schr., Dantz. Naturf. Ges., 1820.—STEINHEIM, (L.,) Die Entwickelung der Frösche, Hamburg, 1820, 8vo. fig.—HASSELT, (J. CONR., VAN,) Dissert. exhibens Observationes de metamorphosi quarumdam partium Ranæ temporariæ, Göttingæ, 1820, 8vo.—PREVOST, (J. L.,) et LEBERT, Mémoire sur la formation des organes de la circulation et du Sang dans les Batraciens, Ann. Sc. Nat., 3e sér. I. p. 193, fig.—RUSCONI, (M.,) Développement de la Grenouille commune, depuis le moment de sa naissance jusqu' à son état parfait, Milan, 1828, 4to. fig.—Amours des Salamandres aquatiques et développement du Têtard de ces Salamandres, etc., Milan, 1822, 4to. fig.—BAER, (K. E. v.,) Die Metamorphose des Eies der Batrachier vor der Erscheinung des Embryo, etc., Müller's Archiv, 1834, p. 481.—Entwickelungsgeschichte, etc., vol. 2d, p. 280.—REICHERT, (K. B.,) Das Entwickelungsleben im Wirbelthierreich, Berlin, 1840, 4to. fig.—Vergleichende Entwickelungsgeschichte des Kopfes der nackten Amphibien, etc., Königsberg, 1838, 4to. fig.—Ueber den Furchungsprocess der Batrachier-Eier, Müller's Archiv, 1841, p. 523.—VOGT, (C.,) Untersuchungen über die Entwickelungsgeschichte der Geburtshelfer-

investigations, extending over a variety of families, so much needed, as in that of Birds, though the general development of these animals is, perhaps, better known than that of any other type;[1] while the class of Mammalia[2] has found in Bischoff a most successful and thorough investigator.[3]

kröte, Solothurn, 1841, 4to. fig. — Quelques observations sur l'embryologie des Batraciens, Ann. Sc. n., 3e sér. vol. 2, p. 45. — REMAK, (R.,) Untersuchungen über die Entwickelung der Wirbelthiere, Berlin, 1855, fol. — NEWPORT, (G.,) On the Impregnation of the Ovum in the Amphibia, Philos. Trans. R. Soc., 1851, I., p. 169. — WITTICH, (W. H. v.,) Beiträge zur morphologischen und histologischen Entwickelung der Harn- und Geschlechtswerkzeuge der nackten Amphibien, Zeitsch. f. wiss. Zool., 1852, vol. 4, p. 125. — WEINLAND, (D.,) Ueber den Beutelfrosch, Müller's Archiv, 1854, p. 449. — WYMAN, (J.,) Observations on Pipa americana, Am. Jour. Sc. and Arts, 2d ser. 1854, vol. 17, p. 369.

[1] PANDER, (CHR. H.,) Diss. sistens historiam metamorphoseos quam ovum incubatum prioribus quinque diebus subit, Wirceb. 1817, 8vo. — Beiträge zur Entwickelungsgeschichte des Hühnchens im Eie, Würzb. 1817, fol. fig. — BAER, (K. E. v.,) Entwickelungsgeschichte, etc., vol. 1. — DUTROCHET, (H.,) Histoire de l'œuf des Oiseaux avant la ponte, Bull. Soc. Philom., 1819, p. 38. — HUNTER, (JOHN,) Observations on Animal Development, edited and his Illustrations of that process in the Bird described by R. OWEN, London, 1841, fol. fig. — PREVOST, (J. L.,) Mémoire sur le développement du poulet dans l'œuf, Ann. Sc. Nat., 1827, vol. 12, p. 415. — PREVOST, (J. L.,) et LEBERT, Mémoires sur la formation des organes de la circulation et du sang dans l'embryon du Poulet, Ann. Sc. Nat. 3e sér. I. p. 265; II. p. 222, fig.; III. p. 96. — BAUDRIMONT, (A.,) et MARTIN ST. ANGE, (G. J.) Recherches anatomiques et physiologiques sur le développement du fœtus, Paris, 1850, 4to. — MECKEL v. HEMSBACH, (H.,) Die Bildung der für partielle Furchung bestimmten Eier der Vögel, etc., Zeitsch. f. wiss. Zool., 1852, vol. 3, p. 420. — In no class are embryological investigations extending over a variety of families more needed than in that of Birds, if we should ever derive any assistance from the knowledge of their development for their natural classification.

[2] For the papers relating to the fœtal envelopes and the placenta and also to the different systems of organs or any organ in particular and for human embryology generally, see Bischoff's article "Entwickelungsgeschichte," in R. Wagner's Handwörterbuch der Physiologie, p. 867, where every thing that has been done in this direction, up to the year 1843, is enumerated. For more recent researches upon these topics consult, also, MÜLLER's Archiv, WIEGMAN's Archiv, SIEBOLD und KÖLLIKER's Zeitsch. f. wiss. Zool., MILNE-EDWARDS, Ann. Sc. Nat., and the Annals and Magazine of Nat. Hist., etc.

[3] BISCHOFF, (TH. L. W.,) Entwickelungsgeschichte des Kaninchen-Eies, Braunschweig, 1842, 4to. fig. — Entwickelungsgeschichte des Hunde-Eies, Braunschweig, 1845, 4to. fig. — Entwickelungsgeschichte des Meerschweinchens, Giessen, 1852, 4to. fig. — Entwickelungsgeschichte des Rehes, Giessen, 1854, 4to. fig. — PREVOST, (J. L.,) et DUMAS, (J. A.,) De la génération chez les Mammifères, etc., Ann. Sc. Nat. 1824, vol. 3, p. 113, fig. — BOJANUS, (L.,) Observatio anatomica de fœtu canino 24 dierum, etc., Act. Ac. Nat. Cur., vol. 10, p. 139, fig. — COSTE, (P.,) Embryogénie comparée, Paris, 1837, 8vo. Atlas 4to. — Histoire particulière et générale du développement des corps organisés, q. a. — Recherches sur le génération des Mammifères et le développement de la brebis. Ann. Sc. Nat., 1835, III. p. 78. — Recherches sur la génération des Mammifères, Paris, 1834, 4to. fig. — BERNHARDT, (C. A.,) Symbolæ ad Ovi Mammalium historiam ante pregnationem, Vratisl., 4to., Müller's Arch., 1835, p. 228. — BARRY, (M.,) Researches in Embryology, Phil. Trans. R. Soc. 1838, p. 301; 1839, p. 307; 1840, p. 529; 1841, p. 195. — BAER, (K. E. v.,) q. a. — OWEN, (R.,) On the Ova of the Ornithorhynchus paradoxus, Phil. Trans. 1834, p. 555. — On the Young of the Ornithorhynchus para-

Embryology has, however, a wider scope than to trace the growth of individual animals, the gradual building up of their body, the formation of their organs, and all the changes they undergo in their structure and in their form; it ought also to embrace a comparison of these forms and the successive steps of these changes between all the types of the animal kingdom, in order to furnish definite standards of their relative standing, of their affinities, of the correspondence of their organs in all their parts. Embryologists have thus far considered too exclusively, the gradual transformation of the egg into a perfect animal; there remains still a wide field of investigation to ascertain the different degrees of similarity between the successive forms an animal assumes until it has completed its growth, and the various forms of different kinds of full-grown animals of the same type; between the different stages of complication of their structure in general, and the perfect structure of their kindred; between the successive steps in the formation of all their parts and the various degrees of perfection of the parts of other groups; between the normal course of the whole development of one type compared with that of other types, as well as between the ultimate histological differences which all exhibit within certain limits. Though important fragments have been contributed upon these different points, I know how much remains to be done, from the little I have as yet been able to gather myself, by systematic research in this direction.

I have satisfied myself long ago, that Embryology furnishes the most trustworthy standard to determine the relative rank among animals. A careful comparison of the successive stages of development of the higher Batrachians furnishes, perhaps, the most striking example of the importance of such investigations. The earlier stages of the Tadpole exemplify the structure and form of those Ichthyoids which have either no legs, or very imperfect legs, with and without external gills; next it assumes a shape reminding us more of the Tritons and Salamanders, and ends with the structure of the Frog or Toad.[1] A comparison between the two latter families might prove further, that the Toads are higher than the Frogs, not only on account of their more terrestrial habits (see Sect. 16), but because the embryonic web, which, to some extent, still unites the fingers in the Frogs, disappears entirely in the Toads, and may be also, because glands are developed in their skin, which do not exist in Frogs. A similar comparison of the successive changes of a new species of Comatula discovered by Prof. Holmes, in the harbor of Charleston, in South Carolina, has shown me in what relation the different types of Crinoids of past ages stand to

doxus, Trans. Zool. Soc., i. p. 221; Proc. Zoöl. Soc., ii. p. 43; Ann. Sc. Nat., 2d ser. ii. p. 303; iii. p. 299. — On the Generation of the Marsupial Animals, etc., Phil. Trans., 1824, p. 333. — MEIGS, (CH.,) Observations on the Reproductive Organs and on the Fœtus of Delphinus Nesarnak, Journ. Ac. Nat. Sc. Phil., new ser. 1849, vol. 1, p. 267.

[1] AGASSIZ, (L.,) Twelve Lectures, etc., page 8.

these changes, and has furnished a standard to determine their relative rank; as it cannot be doubted, that the earlier stages of growth of an animal exhibit a condition of relative inferiority, when contrasted with what it grows to be, after it has completed its development, and before it enters upon those phases of its existence which constitute old age, and certain curious retrograde metamorphoses observed among parasites.

In the young Comatula there exists a stem, by which the little animal is attached, either to sea weeds, or to the cirrhi of the parent; the stem is at first simple and without cirrhi, supporting a globular head, upon which the so-called arms are next developed and gradually completed by the appearance of branches; a few cirrhi are, at the same time, developed upon the stem, which increase in number until they form a wreath between the arms and the stem. At last, the crown having assumed all the characters of a diminutive Comatula, drops off, freeing itself from the stem, and the Comatula moves freely as an independent animal.[1]

The classes of Crustacea and of Insects,[2] are particularly instructive in this respect. Rathke, however, has described the transformations of so many Crustacea, that I cannot do better than to refer to his various papers upon this subject,[3] for details relating to the changes these animals undergo during their earlier stages of growth. I would only add, that while the embryo of the highest Crustacea, the Brachyura, resembles by its form and structure the lowest types of this class, as the Entomostraca and Isopoda, it next assumes the shape of those of a higher order, the Macroura, before it appears with all the characteristics of the Brachyura.

Embryology furnishes, also, the best measure of the true affinities existing between animals. I do not mean to say, that the affinities of animals can only be ascertained by embryonic investigations; the history of Zoölogy shows, on the contrary, that even before the study of the formation and growth of animals had become a distinct branch of physiology, the general relationship of most animals had already been determined, with a remarkable degree of accuracy, by anatomical investigations. It is, nevertheless, true, that in some remarkable instances, the knowledge of the embryonic changes of certain animals gave the first clue to their true affinities, while, in other cases, it has furnished a very welcome confirmation of relationships, which, before, could appear probable, but were still very problematical. Even Cuvier considered, for instance, the Barnacles as a distinct class, which he placed

[1] A condensed account of the transformations of the European Comatula, may be found in E. FORBES'S History of the British Starfishes, p. 10. The embryology of our species will be illustrated in one of my next volumes.

[2] See AGASSIZ'S Twelve Lectures, p. 62, and Classification of Insects, etc., q. a. It is expected that Embryology may furnish the means of ascertaining the relative standing of every family.

[3] See above, page 79, note 2.

among Mollusks, under the name of Cirripeds. It was not until Thompson[1] had shown, what was soon confirmed by Burmeister and Martin St. Ange, that the young Barnacle has a structure and form identical with that of some of the most common Entomostraca, that their true position in the system of animals could be determined; when they had to be removed to the class of Crustacea, among Articulata. The same was the case with the Lernæans, which Cuvier arranged with the Intestinal Worms, and which Nordmann has shown upon embryological evidence to belong also to the class of Crustacea.[2] Lamarck associated the Crinoids with Polypi, and though they were removed to the class of Echinoderms by Cuvier, before the metamorphoses of the Comatula were known,[3] the discovery of their pedunculated young furnished a direct proof that this was their true position.

Embryology affords further a test for homologies in contradistinction of analogies. It shows that true homologies are limited respectively within the natural boundaries of the great branches of the animal kingdom.

The distinction between homologies and analogies, upon which the English naturalists have first insisted,[4] has removed much doubt respecting the real affinities of animals which could hardly have been so distinctly appreciated before. It has taught us to distinguish between real affinity, based upon structural conformity, and similarity, based upon mere external resemblance in form and habits. But even after this distinction had been fairly established, it remained to determine within what limits homologies may be traced. The works of Oken, Spix, Geoffroy, and Carus,[5] show to what extravagant comparisons a preconceived idea of unity may lead. It was not until Baer had shown that the development of the four great branches of the animal kingdom is essentially different,[6] that it could even be suspected that organs performing identical functions may be different in their essential relations to one another, and not until Rathke[7] had demonstrated that the yolk is in open communication with the main cavity of the Articulata, on the dorsal side of the animal, and not on the ventral side, as in Vertebrata, that a solid basis was obtained for the natural limitation of true homologies. It now appears more and more distinctly, with every step of the progress Embryology is making, that the structure of animals is only homologous within the limits of the four great branches

[1] THOMPSON's Zool. Researches, etc.; BURMEISTER's Beiträge, etc.; MARTIN ST. ANGE, Mém. sur l'organisation, etc., quoted above, page 79, note 1.

[2] NORDMANN's Micrographische Beyträge, q. a.

[3] THOMPSON and FORBES, q. a., page 79.

[4] SWAINSON's Geography and Classification, etc. See above, Sect. V., p. 20.

[5] See, above, Sect. IV., notes 1 and 2.

[6] BAER's Entwickelungsgeschichte, vol. 1, p. 160 and 224. The extent of Baer's information and the comprehensiveness of his views, nowhere appear so strikingly as in this part of his work.

[7] RATHKE's Unters. über Bild., etc., see, above, p. 79, note 2.

of the animal kingdom, and that general homology strictly proved, proves also typical identity, as special homology proves class identity.

The results of all embryonic investigations of modern times go to show more and more extensively, that animals are entirely independent of external causes in their development. The identity of the metamorphoses of oviparous and viviparous animals belonging to the same type, furnishes the most convincing evidence to that effect.[1] Formerly it was supposed that the embryo could be affected directly by external influences to such an extent, that monstrosities, for instance, were ascribed to the influence of external causes. Direct observation has shown, that they are founded upon peculiarities of the normal course of their development.[2] The snug berth in which the young undergo their first transformation in the womb of their mother in all Mammalia, excludes so completely the immediate influence of any external agent, that it is only necessary to allude to it, to show how independent their growth must be of the circumstances in which even the mother may be placed. This is equally true of all other viviparous animals, as certain snakes, certain sharks, and the viviparous fishes. Again, the uniformity of temperature in the nests of birds, and the exclusion, to a certain degree, of influences which might otherwise reach them, in the various structures animals build for the protection of their young or of their eggs,[3] show distinctly, that the instinct of all animals leads them to remove their progeny from the influence of physical agencies, or to make these agents subservient to their purposes, as in the case of the ostrich. Reptiles and terrestrial Mollusks bury their eggs to subtract them from varying influences; fishes deposit them in localities where they are exposed to the least changes. Insects secure theirs

[1] This seems the most appropriate place to remark, that the distinction made between viviparous and oviparous animals is not only untenable as far as their first origin in the egg is concerned, but also unphysiological, if it is intended, by this designation, to convey the idea of any affinity or resemblance in their respective modes of development. Fishes show more distinctly than any other class, that animals, the development of which is identical, in all its leading features, may either be viviparous or oviparous; the difference here arising only from the connection in which the egg is developed, and not from the development itself. Again, viviparous and oviparous animals of different classes differ greatly in their development, even though they may agree in laying eggs or bringing forth living young. The essential feature upon which any important generalization may be based, is, of course, the mode of development of the germ. In this respect we find that Selachians, whether oviparous or viviparous, agree with one another; this is also the case with the bony fishes and the reptiles, whether they are respectively oviparous or viviparous; even the placentalian and non-placentalian Mammalia agree with one another in what is essential in their development. Too much importance has thus far been attached to the connections in which the germ is developed, to the exclusion of the leading features of the transformations of the germ itself.

[2] BISHOFF, (TH. L. W.,) in R. Wagner's Handwörterbuch der Physiologie, Article "Entwickelungsgeschichte," p. 885.

[3] BURDACH'S Physiologie, etc., q. a. vol. 2, 2d ed. Sect. 334–38. See, also, KIRBY and SPENCE'S Introduction, etc., q. a.

in various ways. Most marine animals living in extreme climates, lay their eggs in winter, when the variations of external influences are reduced to a minimum. Everywhere we find evidence that the phenomena of life, though manifested in the midst of all the most diversified physical influences, are rendered independent of them to the utmost degree, by a variety of contrivances prepared by the animals themselves, in self-protection, or for the protection of their progeny from any influence of physical agents not desired by them, or not subservient to their own ends.

SECTION XIX.

DURATION OF LIFE.

There is the most extraordinary inequality in the average duration of the life of different kinds of animals and plants. While some grow and reproduce themselves and die in a short summer, nay, in a day, others seem to defy the influence of time.[1]

Who has thus apportioned the life of all organized beings? To answer this question, let us first look at the facts of the case. In the first place, there is no conformity between the duration of life and either the size, or structure, or habitat of animals; next, the system, in which the changes occurring during any period are regulated, differs in almost every species, there being only a slight degree of uniformity between the representatives of different classes, within certain limits.

In most Fishes and the Reptiles proper, for instance, the growth is very gradual and uniform, and their development continues through life, so much so that their size is continually increasing with age.

In others, the Birds, for instance, the growth is rapid during the first period of their life, until they have acquired their full size, and then follows a period of equilibrium, which lasts for a longer or shorter period in different species.

In others still, which also acquire within certain limits a definite size, the Mammalia, for instance, the growth is slower in early life, and maturity is attained, as in man, at an age which forms a much longer part of the whole duration of life.

In Insects, the period of maturity is, on the contrary, generally the shortest, while the growth of the larva may be very slow, or, at least, that stage of development last for a much longer time than the life of the perfect Insects. There is no

[1] SCHÜBLER, (GUST.,) Beobachtungen über jährliche periodisch wiederkehrende Erscheinungen im Thier- und Pflanzenreich, Tübingen, 1831, 8vo.—QUETELET, (A.,) Phénomènes périodiques, Ac. Brux.

more striking example of this peculiar mode of growth than the seventeen years locust, so fully traced by Miss M. H. Morris.[1]

While all longlived animals continue, as a matter of course, their existence through a series of years, under the varying influence of successive seasons, there are many others which are periodical in their appearance; this is the case with most insects,[2] but perhaps in a still more striking manner with Medusæ.[3]

The most interesting point in this subject is yet the change of character which takes place in the different stages of growth of one and the same animal. Neither Vertebrata, nor Mollusks, nor even Radiata exhibit in this respect any thing so remarkable in the continuous changes which an individual animal may undergo, as the Insects, and among them those with so-called complete metamorphoses, in which the young (the larva) may be an active, wormlike, voracious, even carnivorous being, which in middle life (the chrysalis) becomes a mummylike, almost motionless maggot, incapable of taking food, ending life as a winged and active insect. Some of these larvæ may be aquatic and very voracious, when the perfect insect is aërial and takes no food at all.[4]

Is there any thing in this regulation of the duration of life in animals which recalls the agency of physical forces? Does not, on the contrary, the fact, that while some animals are periodical and bound to the seasons in their appearance, and others are independent of the course of the year, show distinctly their independence of all those influences which, under a common expression, are called physical causes? Is this not further illustrated in the most startling manner by the extraordinary changes, above alluded to, which one and the same animal may undergo during different periods of its life? Does this not prove directly the immediate intervention of a power capable of controlling all these external influences, as well as regulating the course of life of every being, and establishing it upon such an immutable foundation, within its cycle of changes, that the uninterrupted action of these agents shall not interfere with the regular order of their natural existence?

There is, however, still another conclusion to be drawn from these facts: they point distinctly at a discriminating knowledge of time and space, at an appreciation of the relative value of unequal amounts of time and an unequal repartition of small, unequal periods over longer periods, which can only be the attribute of a thinking being.

[1] HARRIS's Insects injurious to Vegetation, p. 184.

[2] HEROLD, (E.,) Teutscher Raupen-Kalender, Nordhausen, 1845.

[3] AGASSIZ's Acalephs of North America, p. 228.

[4] BURMEISTER's Handb. d. Entom. etc. — LACORDAIRE, Introd. à l'Entomologie, etc. — KIRBY and SPENCE, Introd. to Entomol., etc., q. a., give accounts of the habits of Insects during their metamorphosis.

SECTION XX.

ALTERNATE GENERATIONS.

While some animals go on developing gradually from the first formation of their germ to the natural end of their life, and bring forth generation after generation, a progeny which runs with never varying regularity through the same course, there are others which multiply in various ways, by division and by budding,[1] or by a strange succession of generations, differing one from the other, and not returning, by a direct course, to their typical cycle.

The facts which have led to the knowledge of the phenomena now generally known under the name of *alternate generation*, were first observed by Chamisso and Sars, and afterwards presented in a methodical connection by Steenstrup, in his famous pamphlet on that subject.[2] As a brief account of the facts may be found in almost every text-book of Physiology, I need not repeat them here, but only refer to the original investigations, in which all the details known upon this subject may be found.[3] These facts show, in the first place with regard to Hydroid Medusæ, that the individuals born from eggs, may be entirely different from those which produced the eggs, and end their life without ever undergoing themselves such changes as would transform them into individuals similar to their parents;[4] they show further,

[1] Much information useful to the zoölogist, may be gathered from BRAUN's paper upon the Budding of Plants, q. a., p. 18, note 3. The process of multiplication by budding or by division, and that of sexual reproduction, are too often confounded by zoölogists, and this confusion has already led to serious misconstructions of well known facts.

[2] STEENSTRUP, (J.,) Ueber den Generationswechsel, q. a., p. 69, note 3.

[3] See the works quoted above, page 69, note 3, and p. 70, note 1, also CARUS, (V.,) Zur nähern Kenntniss des Generationswechsels, Leipzig, 1849, 8vo. — Einige Worte über Metamorphose und Generationswechsel, Zeitsch. f. wiss. Zool., 1851, vol. 3, p. 359. — OWEN, (R.,) On Parthenogenesis, or the Successive Production of Procreating Individuals from a single Ovum, London, 1849, 8vo. — On Metamorphosis and Metagenesis, Ann. and Mag. Nat. Hist., 2d ser. vol. 8, 1857, p. 59. — PROSCH, (V.,) Om Parthenogenesis og Generationsvexel et Bidrag til Generationslæren, Kiöbenhavn, 1851. — LEUCKART, (R.,) Ueber Metamorphose, ungeschlechtliche Vermehrung, Generationswechsel, Zeitsch. f. wiss. Zool., vol. 3, 1851. — DANA, (J. D.,) On the Analogy between the Mode of Reproduction in Plants and the "Alternation of Generations" observed in some Radiata, Amer. Journ. A. and Sc., 2d ser. vol. 10, p. 341. — EHRENBERG, (C. G.,) Ueber die Formenbeständigkeit und den Entwickelungskreis der organischen Formen, Monatsber. der Akad., Berlin. 1852, 8vo.

[4] Polymorphism among individuals of the same species is not limited to Acalephs; it is also observed among genuine Polyps, the Madrepores, for example, and among Bryozoa, Ascidians, Worms, Crustacea (Lupea), and even among Insects (Bees).

that this brood originating from eggs, may increase and multiply by producing new individuals like themselves (Syncoryne), or of two kinds (Campanularia), or even individuals of various kinds, differing all to a remarkable extent, one from the other, (Hydractinia,) but in neither case resembling their common parent. None of these new individuals have distinct reproductive organs, any more than the first individuals born from eggs, their multiplication taking place chiefly by the process of budding; but as these buds remain generally connected with the first individual born from an egg, they form compound communities, similar to some polypstocks. Now some of these buds produce, at certain seasons, new buds of an entirely different kind, which generally drop off from the parent stock, at an early period of their development, (as in Syncoryna, Campanularia, etc.,) and then undergo a succession of changes, which end by their assuming the character of the previous egg-laying individuals, organs of reproduction of the two sexes developing meanwhile in them, which, when mature, lead to the production of new eggs; in others (as in Hydractinia,) the buds of this kind do not drop off, but fade away upon the parent stock, after having undergone all their transformations, and also produced in due time, a number of eggs.[1]

In the case of the Medusæ proper,[2] the parent lays eggs, from which originate polyplike individuals; but here these individuals divide by transverse constrictions into a number of disks, every one of which undergoes a succession of changes, which end in the production of as many individuals, each identical with the parent, and capable in its turn, of laying eggs, (some, however, being males and others females.) But the polyplike individuals born from eggs may also multiply by budding and each bud undergo the same changes as the first, the base of which does not die, but is also capable of growing up again and of repeating the same process.

In other classes other phenomena of a similar character have been observed, which bear a similar explanation. J. Müller[3] has most fully illustrated the alternate generations of the Echinoderms; Chamisso, Steenstrup, Eschricht, Krohn, and Sars, those of the Salpæ;[4] von Siebold, Steenstrup, and others, those of certain Intestinal Worms.[5]

This alternate generation differs essentially from metamorphosis, though some

[1] I have observed many other combinations of a similar character among the Hydroid Medusæ, which I shall describe at full length in my second volume; and to which I do not allude here, as they could not be understood without numerous drawings. The case of Hydractinia is not quite correctly represented in the works in which that animal has been described. Respecting Physalia and the other Siphonophora, see the works quoted above, p. 69, note 3.

[2] See SIEBOLD, and SARS, q. a., p. 69, note 3.

[3] MÜLLER, (J.,) Ueber den allgemeinen Plan, etc., q. a., p. 70, note 1.

[4] See the works, q. a., page 72, note 4.

[5] See the works, q. a., page 76, note 2, and 77, note 1.

writers have attempted to identify these two processes. In metamorphosis, as observed among Insects, the individual born from an egg goes on undergoing change after change, in direct and immediate succession, until it has reached its final transformation; but however different it may be at different periods of its life, it is always one and the same individual. In alternate generations, the individual born from an egg never assumes through a succession of transformations the character of its parent, but produces, either by internal or external budding or by division, a number, sometimes even a large number of new individuals, and it is this progeny of the individuals born from eggs, which grows to assume again the characters of the egg-laying individuals.

There is really an essential difference between the sexual reproduction of most animals, and the multiplication of individuals in other ways. In ordinary sexual reproduction, every new individual arises from an egg, and by a regular succession of changes assumes the character of its parents. Now, though all species of animals reproduce their kind by eggs, and though in each there is at least a certain number of individuals, if not all, which have sprung from eggs, this mode of reproduction is not the only one observed among animals. We have already seen how new individuals may originate from buds, which in their turn may produce sexual individuals; we have also seen how, by division, individuals may also produce other individuals differing from themselves quite as much as the sexual buds, alluded to above, may differ from the individuals which produce them. There are yet, still other combinations in the animal kingdom. In Polyps, for instance, every bud, whether it is freed from the parent stock or not, grows at once up to be a new sexual individual; while in many animals which multiply by division, every new individual thus produced assumes at once the characters of those born from eggs.[1] There is, finally, one mode of reproduction which is peculiar to certain Insects, in which several generations of fertile females follow one another, before males appear again.[2]

What comprehensive views the physical agents must be capable of taking, and what a power of combination they must possess, to be able to ingraft all these complicated modes of reproduction upon structures already so complicated! — But if we turn away from mere fancies and consider the wonderful phenomena just alluded to, in all their bearings, how instructive they appear with reference to this very question of the influence of physical agents upon organized beings! For here we have animals endowed with the power of multiplying in the most extraordinary ways, every species producing new individuals of its own kind, differing to the utmost from their parents. Does this not seem, at first, as if we had before us a perfect

[1] MILNE-EDWARDS, Rech. anat. et zool. faites pendant un Voyage sur les côtes de Sicile, 3 vols. 4to. fig.

[2] OWEN, Parthenogenesis, etc., q. a., p. 90.—BONNET, (CH.,) Traité d'Insectologie, etc., Paris, 1745.

exemplification of the manner in which different species of animals may originate, one from the other, and increase the number of types existing at first? And yet, with all this apparent freedom of transformation, what do the facts finally show? That all these transformations are the successive terms of a cycle, as definitely closed within precise limits, as in the case of animals, the progeny of which resembles for ever the immediate parent, in all successive generations. For here, as everywhere in the organic kingdoms, these variations are only the successive expressions of a well regulated cycle, ever returning to its own type.

SECTION XXI.

SUCCESSION OF ANIMALS AND PLANTS IN GEOLOGICAL TIMES.

Geologists hardly seem to appreciate fully, the whole extent of the intricate relations exhibited by the animals and plants whose remains are found in the different successive geological formations. I do not mean to say, that the investigations we possess respecting the zoölogical and botanical characters of these remains are not remarkable for the accuracy and for the ingenuity with which they have been traced. On the contrary, having myself thus far devoted the better part of my life to the investigation of fossil remains, I have learned early, from the difficulties inherent in the subject, better to appreciate the wonderful skill, the high intellectual powers, the vast erudition displayed in the investigations of Cuvier and his successors upon the faunæ and floræ of past ages.[1] But I cannot refrain

[1] CUVIER, (G.,) Recherches sur les Ossemens fossiles de Quadrupèdes, etc., Paris, 1812, 4 vols. 4to.; nouv. édit. Paris, 1821–23, 5 vols. 4to.; 4e édit. 10 vols. 8vo. and 2 vols. pl. 4to. — SOWERBY, (JAMES,) The Mineral Conchology of Great Britain, London, 1812–19, 6 vols. 8vo. fig. — SCHLOTTHEIM, (E. F. v.,) Die Petrefactenkunde, etc., Gotha, 1820, 8vo. fig. — LAMARCK, (J. B. DE,) Mémoires sur les fossiles des environs de Paris, Paris, 1823, 4to. fig. — GOLDFUSS, (G. A.,) Petrefacta Germaniæ, Düsseldorf, 1826–33, fol. fig. — STERNBERG, (KASPAR, M. GR. v.,) Versuch einer geognostisch-botanischen Darstellung der Flora der Vorwelt, Leipzig und Prag, 1820–38, fol. fig. — BRONGNIART, (AD.,) Prodrome d'une Histoire des Végétaux fossiles, Paris, 1818, 2 vols. 8vo. — Histoire des Végétaux fossiles, Paris, 1828–43, 2 vols. 4to. fig. — LINDLEY, (J.,) and HUTTON, (W.,) The Fossil Flora of Great Britain, London, 1831–37, 3 vols. 8vo. — GÖPPERT, (H. R.,) Systema Filicum fossilium, Vratisl. et Bonnæ, 1836, 4to. fig. — Die Gattungen der fossilen Pflanzen, verglichen mit denen der Jetztwelt, etc., Bonn, 1841–48, 4to. fig. — Monographie der fossilen Coniferen. Düsseldorf, 1850, 4to. fig. — More special works are quoted hereafter, but only such works shall be mentioned, which have led on, in the progress of Geology and Palæontology, or contain full reports of the present state of our science, and also such as have special reference to America. References to the description of species may be found in BRONN,

from expressing my wonder at the puerility of the discussions in which some geologists allow themselves still to indulge, in the face of such a vast amount of well digested facts as our science now possesses. They have hardly yet learned to see that there exists a definite order in the succession of these innumerable extinct beings; and of the relations of this gradation to the other great features exhibited by the animal kingdom, of the great fact, that the development of life is the prominent trait in the history of our globe,[1] they seem either to know nothing, or to look upon it only as a vague speculation, plausible perhaps, but hardly deserving the notice of sober science.

It is true, Palæontology as a science is very young; it has had to fight its course through the unrelenting opposition of ignorance and prejudice. What amount of labor and patience it has cost only to establish the fact, that fossils are really the remains of animals and plants that once actually lived upon earth,[2] only those know, who are familiar with the history of science. Then it had to be proved, that they are not the wrecks of the Mosaic deluge, which, for a time, was the prevailing opinion, even among scientific men.[3] After Cuvier had shown, beyond question, that they are the remains of animals no longer to be found upon earth, among the living, Palæontology acquired for the first time a solid basis. Yet what an amount of labor it has cost to ascertain, by direct evidence, how these remains are distributed in the solid crust of our globe, what are the differences they exhibit in successive formations,[4] what is their geographical distribution, only those can

(H. G.,) Index palæontologicus, Stuttgart, 1848–49, 3 vols. 8vo. — See also, KEFERSTEIN, (CHR.,) Geschichte und Literatur der Geognosie, Halle, 1840, 1 vol. 8vo. — ARCHIAC, (VIC. D',) Histoire des progrès de la Géologie, Paris, 1847, et suiv, 4 vols. 8vo.; and the Transactions, Journals, and Proceedings of the Geological Society of London, of Paris, of Berlin, of Vienna, etc.; also, LEONHARD and BRONN's Neues Jahrbuch, etc.

[1] AGASSIZ's Geological Times, etc., q. a., p. 25, note 2. — DANA's Address to the Amer. Ass. for Adv. Sc. 8th Meeting, held at Providence, 1855.

[2] SCILLA, (AG.,) La vana speculazione desingannata dal senso. Napoli, 1670, 4to. fig.

[3] SCHEUCHZER, (J. J.,) Homo Diluvii testis et Θεόσκοπος, Tiguri, 1726, 4to. — BUCKLAND, (W.,) Reliquiæ diluvianæ, or Observations on the Organic Remains attesting the Action of an Universal Deluge, London, 1826, 4to. fig.

[4] For references respecting the fossils of the oldest geological formations, see the works, quoted above, p. 23, note 1. Also, MCCOY, (F.,) Synopsis of the Silurian Fossils of Ireland, Dublin, 1846, 4to. fig. — GEINITZ, (H. D.,) Die Versteinerungen der Grauwackenformation, Leipzig, 1850–53, 4to. fig. — And for local information, the geological reports of the different States of the Union, a complete list of which, with a summary of the Geology, may be found in MARCOU's (J.,) Résumé explicatif d'une carte géologique des Etats-Unis, Bull. Soc. Géol. de France, Paris, 1855, 2de sér. vol. 12. — For the *Devonian system:* PHILLIPS, (JOHN,) Figures and Descriptions of the Palæozoic Fossils of Cornwall, Devon, and Westsomerset, etc., London, 1841, 8vo. — ARCHIAC, (VIC. D',) and VERNEUIL, (ED. DE,) Memoir on the Fossils of the Older Deposits in the Rhenish Provinces, Paris, 1842, 4to. fig. — SANDBERGER, (G. UND FR.,) Systematische Beschreibung

fully appreciate, who have had a hand in the work.[1] And even now, how many important questions still await an answer!

und Abbildung der Versteinerungen des Rheinischen Schichtensystems in Nassau, Wiesbaden, 1850–54, 4to. fig. — For the *Carboniferous period:* PHILLIPS, (J.,) Illustrations of the Geology of Yorkshire, London, 1836, 2d vol., 4to. fig. — DEKONINCK, (L.,) Descriptions des animaux fossiles qui se trouvent dans le terrain houiller de la Belgique, Liège, 1842, 2 vols. 4to. fig.; suppl., etc. — MCCOY, (FR.,) Synopsis of the Carboniferous Fossils of Ireland, Dublin, 1844, 4to. fig. — GERMAR, (E. FR.,) Die Versteinerungen des Steinkohlengebirges, Halle, 1844–53, fol. fig. — GEINITZ, (H. B.,) Die Versteinerungen der Steinkohlenformation, Leipzig, 1855, fol. fig. — For the *Permian system:* QUENSTEDT, (A.,) Ueber die Identität der Petrificate des Thüringischen und Englischen Zechsteins, Wiegman's Archiv, 1835, I., p. 75. — GEINITZ, (H. B.,) und GUTBIER, (A.,) Die Versteinerungen des Zechsteingebirges, etc., Dresden, 1849, 4to. fig. — KING, (W.,) Monograph of the Permian Fossils of England, (Palæont. Soc.,) London, 1850, 4to. fig. — For the *Triasic system:* ALBERTI, (FR. v.,) Beitrag zur einer Monographie des bunten Sandsteins, Mushelkalks, und Keupers, Stuttgart und Tübingen, 1834, 8vo. — For the *Jura*, PHILLIPS, (J.,) Illustrations of the Geology of Yorkshire, York, 1829, vol. 1, 4to. fig. — PUSCH, (G. G.,) Polens Palæontologie, etc., Stuttgart, 1836, 4to. fig. — RÖMER, (Fr. A.,) Die Versteinerungen des norddeutschen Oolithen-Gebirges, Hannover, 1836, 4to. fig. — ZIETEN, (C. H. v.,) Die Versteinerungen Würtembergs, Stuttgart, 1830–34, fol. fig. — ORBIGNY, (ALC. d',) Paléontologie française, Paris, 1840–53, 8vo. fig. — MORRIS, (J.,) and LYCETT, (J.,) Mollusca from the Great Oolite, (Palæont. Soc.,) London, 1850–55, 4to. fig. — For the *Cretaceous period:* MORTON, (S. G.,) Synopsis of the Remains of the Cretaceous Group of the United States, Philadelphia, 1834, 8vo. fig. — ORBIGNY, (ALC. d',) Paléont. franç., q. n. — GEINITZ, (H. BR.,) Charakteristik der Schichten und Petrefakten des Kreidegebirges, Dresden, 1839–42, 4to. fig. — PICTET, (F. J.,) et ROUX, (W.,) Description des fossiles qui se trouvent dans les grès verts des environs de Genève, Mém. Soc. Phys., etc., Genève, 1847–52, vol. 12 et 13. — RÖMER, (F. A.,) Die Versteinerungen des norddeutschen Kreidegebirges, Hannover, 1841, 4to. fig. — Die Kreidebildungen von Texas, Bonn, 1852, 4to. fig. — REUSS, (A. E.,) Die Versteinerungen der böhmischen Kreideformation, Stuttgart, 1845–46, 4to. fig. — MÜLLER, (JOS.,) Monographie der Petrefacten der Aachener Kreideformation, Bonn, 1851, 4to. fig. — SHARPE, (D.,) Fossil Remains of Mollusca found in the Chalk of England, (Palæont. Soc.,) London, 1854, 4to. fig. — HALL, (JAMES,) Cretaceous Fossils of Nebraska, Trans. Amer. Acad., 1856, vol. 5. — For the *Tertiaries:* BROCCHI, (G. B.,) Conchiologia fossile subappennina, etc., Milano, 1814–43, 2 vols., 4to. fig. — DESHAYES, (G. P.,) Description des coquilles fossiles des environs de Paris, 1824–37, 3 vols. 4to. Atl. — BRONN, (H. G.,) Italiens Tertiärgebilde, Heidelberg, 1831, 8vo. — LEA, (I.,) Contributions to Geology, Philadelphia, 1833, 8vo. fig. — CONRAD, (T. A.) Fossil Shells of the Tertiary Formations of North America, Philadelphia, 1832–36, 8vo. fig. — GRATELOUP, (DR.,) Conchyliologie fossile du bassin de l'Adour, etc., Bordeaux, 1837, 8vo. fig. — MATHERON, (PH.,) Catalogue méthodique et descriptif des corps organisés fossiles, etc., Marseilles, 1842, 8vo. — BERENDT, (G. C.,) Organische Reste im Bernstein, Berlin, 1845–54, fol. fig. — WOOD, (S. V.,) A Monograph of the Crag Mollusks, (Palæont. Soc.,) 1848–50, 4to. fig. — EDWARDS, (F. E.,) Eocene Mollusca, (Palæont. Soc.,) London, 1849–52, 4to. fig. — HÖRNESS, (M.,) Die fossilen Mollusken des Tertiär-Beckens von Wien, Wien, 1851, 4to. fig. — BEYRICH, (E.,) Die Conchylien des norddeutschen Tertiärgebirges, Berlin, 1854–56, 8vo. fig. — TUOMEY, (M.,) and HOLMES, (FR. S.,) Fossils of South Carolina, Charleston, 1855–56, 4to. fig.

[1] BUCH, (L. v.,) Pétrifications recueillies en Amérique par Mr. Alex. de Humboldt et par Mr. Ch. Degenhard, Berlin, 1838, fol. fig. — ORBIGNY, (ALC. D',) Voyage dans l'Amérique Méridionale, etc., Paris, 1834–43, 7 vols. 8vo. Atl. 4to. — ARCHIAC,

One result, however, stands now unquestioned: the existence during each great geological era[1] of an assemblage of animals and plants differing essentially for each period. And by period I mean those minor subdivisions in the successive sets of beds of rocks, which constitute the stratified crust of our globe, the number of which is daily increasing, as our investigations become more extensive and more precise.[2] What remains to be done, is to ascertain with more and more precision, the true affinities of these remains to the animals and plants now living, the relations of those of the same period to one another, and to those of the preceding and following epochs, the precise limits of these great eras in the development of life, the character of the successive changes the animal kingdom has undergone, the special order of succession of the representatives of each class,[3] their combina-

(VIC. d',) et HAIME, (J.,) Description des animaux fossiles du groupe nummulitique de l'Inde, Paris, 1853, 4to. fig. — LEUCKART, (F. S.,) Ueber die Verbreitung der übriggebliebenen Reste einer vorweltlichen Schöpfung, Freiburg, 1835, 4to.

[1] Geological text-books: DELABECHE, (Sir H. T.,) Geological Manual, London, 1833, 1 vol. 8vo.; German Trans. by Dechen; French by Brochant de Villers. — The Geological Observer, London, 1851, 8vo. — LYELL, (Sir C.,) Manual of Elementary Geology, London, 1851, 1 vol. 8vo. — Principles of Geology, etc., London, 1830, 2 vols. 8vo.; 8th edit., 1850, 1 vol. 8vo. — NAUMANN, (C. FR.,) Lehrbuch der Geognosie, Leipzig, 1850–54, 2 vols. 8vo. Atl. 4to. — VOGT, (C.,) Lehrbuch der Geologie und Petrefaktenkunde, Braunschweig, 1854, 8vo. 2 vols., 2d edit. — Text-books on Fossils: BRONN, (H. G.,) Lethæa Geognostica, Stuttgart, 1835–37, 2 vols., 8vo. Atl. fol.; 3d edit. with FR. RŒMER, 1846, et seq. — PICTET, (F. J.,) Traité élémentaire de Paléontologie, etc., Paris, 1844–45, 4 vols., 8vo. fig.; 2de édit. 1853 et seq., 8vo. Atl. 4to. — ORBIGNY, (ALC. d',) Cours élémentaire de Paléontologie, Paris, 1852, 3 vols., 12mo. — GIEBEL, (E. G.,) Fauna der Vorwelt, Leipzig, 1852, 2 vols. 8vo. — Allgemeine Palæontologie, Leipzig, 1852, 1 vol., 8vo. — QUENSTEDT, (F. A.,) Handbuch der Petrefaktenkunde, Tübingen, 1852, 8vo. fig. Unfortunately, there exists not a single English text-book of Palæontology. A translation of Pictet's and Bronn's works would be particularly desirable.

[2] At first, only three great periods were distinguished, the primary, the secondary, and the tertiary; afterwards, six or seven, (DelaBèche); later, from ten to twelve; now, the number is almost indefinite, at least undetermined in the present stage of our knowledge, when many geologists would only consider as subdivisions of longer periods, what some palæontologists are inclined to consider as distinct periods.

[3] The principal Monographs relating to special classes or families, are the following: *Polyps* and *Infusoria*: MICHELIN, (H.,) Iconographie Zoophytologique, Paris, 1841–45, 4to. fig. — EDWARDS, (H. MILNE,) et HAIME, (J.,) Recherches, etc., q. a., p. 31. — Polypiers fossiles des terrains paléozoiques, Arch. Mus., vol. 5. — Monograph of the British Fossil Corals, Palæont. Soc., London, 1850–55, 4to. fig. — LONSDALE, (W.,) On the Corals from the Tertiary Formations of North America, Journ. Geol. Soc., I., p. 495; Sill. Journ., 2d ser. IV., p. 357. — McCOY, (FR.,) Contributions to British Palæontology, Cambridge, 1854, 1 vol. 8vo. fig. — References to all minor papers may be found in Edwards and Haime's Recherches. — EHRENBERG, (C. G.,) Mikrogeologie, Leipzig, 1854, fol. fig. — *Echinoderms*: MILLER, (J. C.,) A Natural History of the Crinoidea, Bristol, 1821, 4to. fig. — ORBIGNY, (ALC. D',) Histoire naturelle générale et particulière des Crinoides vivans et fossiles, Paris, 1840, 4to. fig. — AUSTIN, (TH. and TH. Jr.,) Monograph on Recent and Fossil Crinoidea, Bristol, 4to. fig. (without date.) — HALL, (J.,)

tions into distinct faunæ during each period, not to speak of the causes, or even the circumstances, under which these changes may have taken place.

Palæont. of New York, q. a.— GOLDFUSS, (G. A.,) Petref. Germ., q. a.— DEKONINCK, (L.,) et LEHON, (H.,) Recherches sur les Crinoides, etc., Bruxelles, 1854, 4to. fig.— OWEN, (D. D.,) and SHUMARD, (B. F.,) Description of New Species of Crinoidea, Journ. Ac. Nat. Sc., Philad. 1850, 4to. fig. — SISMONDA, (E.,) Monographia degli Echinidi fossili del Piemonte, Torino, 1840, 4to. fig.— DESMOULINS, (C.,) Etude sur les Echinides, Bordeaux, 1835–37, 8vo. fig.— AGASSIZ, (L.,) Monogr. Echin., q. a., p. 54.— Catalogue raisonné, etc., q. a., p. 31. I quote this paper under my name alone, because that of Mr. Desor, which is added to it, has no right there. It was added by him, after I had left Europe, not only without authority, but even without my learning it, for a whole year. The genera Goniocidaris, Mespilia, Boletia, Lenita, Gualteria, Lovenia, Breynia, which bear his name, while they should bear mine, as I have established and named them, while Mr. Desor was travelling in Sweden, were appropriated by him, without any more right, by a mere dash of the pen, while he was carrying my manuscript through the press. How many species he has taken to himself, in the same manner, I cannot tell. As the printed work, and a paper presented by me to the Academy of Sciences of Paris, in 1846, exhibit, for every one acquainted with zoölogical nomenclature, internal evidence of my statement, such, for instance, as my name left standing as authority for the species of Mespilia, Lenita, Gualteria, and Breynia, while the genus bears his, I need not allude further to the subject. This is one of the most extraordinary cases of plagiarism I know of.— DESOR, (E.,) Synopsis des Echinides fossiles, Paris, 1854–56, 8vo. fig.; partly reprinted from my Catalogue, with additions and figures.— BUCH, (L. v.,) Ueber die Cystideen, Berlin, 1844, 4to. fig.; Ak. d. wiss.— MÜLLER, (J.,) Ueber den Bau der Echinodermen, Berlin, 1854, 4to. fig.— ROEMER, (F.,) Ueber Stephanocrinus, etc., Wiegm. Arch., 1850, p. 365.— Monographie der fossilen Crinoidenfamilie der Blastoideen, etc., Wiegm. Arch., 1851, p. 323.— FORBES, (ED.,) Echinodermata of the British Tertiaries, (Palæont. Soc.,) 1852, 4to. fig.— Mem. of the Geol. Surv. of the Unit. Kingdom, London, 1849, 8vo. fig., Dec. 1st, 3d, and 4th.— *Mollusks:* DESHAYES, (G. P.,) Traité élémentaire de Conchyliologie, etc., Paris, 1835–39, 2 vols. 8vo. fig.— Description des coquilles caractéristique des terrains, Paris, 1831, 8vo. fig.— WOODWARD, (S. P.,) A Manual of the Mollusca, etc., London, 1851–54, 12mo. fig.— HAGENOW, (FR. V.,) Die Bryozoen der Maastrichter Kreideformation, Cassel, 1851, 4to. fig.— DESMOULINS, (C.,) Essai sur les Sphérulites, Bull. Soc. Lin., Bordeaux, 1827. — ROQUAN, (O. R. DU,) Description des Coquilles fossiles de la famille des Rudistes, etc., Carcassonne, 1841, 4to. fig.— HOENINGHAUS, (FR. W.,) Monographie der Gattung Crania, Düsseldorf, 1828, 4to. fig.— BUCH, (L. V.,) Ueber Terebrateln, etc., Berlin, 1834, 4to. fig.; Ak. d. wiss.— Ueber Productus und Leptæna, Berlin, 1842, 4to. fig.; Ak. d. wiss.— DAVIDSON, (TH.,) British Brachiopoda, (Palæont. Soc.,) London, 1851–55, 4to. fig.— DEKONINCK, (L.,) Recherches sur les animaux fossiles, Liège, 1847, 4to. fig.— AGASSIZ, (L.,) Etudes crit. q. a., p. 54.— FAVRE, (A.,) Observations sur les Diceratcs, Genève, 1843, 4to. fig.— BELLARDI, (L.,) e MICHELOTTI, (G.,) Saggio orittografico sulla classe dei Gasteropodi fossili, Torino, 1840, 4to. fig.— DEHAAN, (W.,) Monographiæ Ammoniteorum et Goniatiteorum Specimen, Lugduni-Batav., 1825, 8vo.— BUCH, (L. V.,) Ueber Ammoniten, über ihre Sonderung in Familien, etc., Berlin, 1832, 4to. fig. Ak. d. wiss.— Ueber Goniotiten und Clymenien in Schlesien, Berlin, 1839, 4to. fig.; Ak. d. wiss.— MÜNSTER, (GR. V.,) Ueber Goniatiten und Planuliten im Uebergangskalk, etc., Baireuth, 1832, 4to. fig.— VOLTZ, (PH. L.,) Observations sur les Bélemnites, Paris, 1830, 4to. fig.— QUENSTEDT, (F. A.,) De Notis Nautileorum primariis, etc., Berolini, 1834, 8vo.— *Crustacea:* BRONGNIART, (AL.,) et DESMAREST, (A. G.,) Histoire naturelle des Trilobites, etc., Paris, 1822, 4to. fig.— DALMAN, (J. W.,) Ueber die Palæaden oder die sogenannten Trilobiten, a. d. Schwed., Nürnberg, In order to be able to compare the order of succession of the animals of past ages with some other prominent traits of the animal kingdom, it is necessary for

1828, 4to. fig. — GREEN, (J.,) A Monograph of the Trilobites of North America, etc., Philadelphia, 1833, 8vo. fig. — EMMERICH, (H. F.,) De Trilobitis, Berolini, 1839, 8vo. fig. — Zur Naturgeschichte der Trilobiten, Meiningen, 1844, 4to. — BURMEISTER, (H.,) Die Organisation der Trilobiten, Berlin, 1843, 4to. fig.; (Ray Society.) — BEYRICH, (E.,) Ueber einige böhmische Trilobiten, Berlin, 1845, 4to.; 2d part, 1846, 4to. — CORDA, (A. J. C.,) und HAWLE, (Ig.,) Prodrom einer Monographie der böhmischen Trilobiten, Prag, 1848, 8vo. fig. — BARRANDE, (J.,) Syst. Sil., q. a., p. 23. — SALTER, (J. W.,) In Mem. Geol. Surv., etc., Dec. 2d. — MÜNSTER, (GR. G. v.,) Beiträge zur Petrefaktenkunde, Beyreuth, 1839, 4to. 2d Fasc., fig. — MEYER, (H. v.,) Neue Gattungen fossiler Krebse, etc., Stuttgart, 1840, 4to. fig. — DE KONINCK, (L.,) Mémoire sur les Crustacés fossiles de Belgique, Liège, 1841, 4to. fig. — CORNUEL, (J.,) Description des Entomostracés fossiles, etc., Mém. Soc. Géol. de France, 2de sér., vol. 1, part 2d, Paris, 1846, 4to. fig. — BOSQUET, Description des Entomostracés fossiles de la Craie de Mæstricht, Mém. Soc. Roy. de Liège, 1847, 8vo. — JONES, (T. R.,) The Entomostraca of the Cretaceous Formation of England, (Palæont. Soc.,) London, 1848, 4to. fig. — DARWIN, (CH.,) Fossil Cirripedia, (Palæont. Soc.,) London, 1851 and 1854, 4to. fig. — *Insects:* BRODIE, (P. B.,) History of the Fossil Insects of the Secondary Rocks of England, London, 1845, 8vo. — HEER, (O.,) Die Insektenfauna der Tertiärgebilde von Oeningen und von Radeboy, Leipzig, 1853, 4to. fig.; N. DENK., helv. Gesellsch. — HEER, (O.,) et ESCHER V. DER LINTH, (A.,) Zwei geologische Vorträge, etc., Zürich, 1852, 4to. — *Fishes:* AGASSIZ, (L.,) Rech. s. les poiss. foss., q. a., p. 54. — EGERTON, (SIR PHIL.,) A Systematic and Stratigraphical Catalogue of the Fossil Fishes, etc., London, 1837, 4to. 2d edit. — On some new Ganoid Fishes, Proc. Geol. Soc. London, IV., p. 183. — On some New Species of Chimæroid Fishes, Ibid., p. 153 and 211, and several other papers in Trans. Geol. Soc. Lond.; Journ. Geol. Soc.; Ann. and Mag. Nat. Hist., and Memoirs of the Geol. Surv. of the United Kingdom, Dec. 6th. — PICTET, (F. J.,) Poissons fossiles du Mt. Liban, Genève, 1850, 4to. fig. — HECKEL, (J. J.,) Beiträge zur Kenntniss der fossilen Fische Oesterreichs, Wien, 1849, 4to. fig. — GIBBES, (R. W.,) Monograph of the Fossil Squalidæ of the United States, Journ. Ac. Nat. Sc., Philadelphia, 1848 and 1849, 4to. fig. — New Species of Myliobates, Ibid., 1849, p. 299. — MCCOY, (F.,) In Sedgwick and McCoy's British Palæoz. Rocks, q. a., p. 23. — NEWBERRY, (J. S.,) Fishes of the Carbonif. Deposits of Ohio, Proc. Ac. Nat. Sc., Philadelphia, 1856. — *Reptiles:* CUVIER, (G.,) Rech. Oss. foss., q. a., p. 93. — JAEGER, (G. FR.,) Ueber die fossilen Reptilien welche in Würtemberg aufgefunden worden sind, Stuttgart, 1828, 4to. fig. — GEOFFROY ST. HILAIRE, (ET.,) Recherches sur les grands Sauriens, etc., Paris, 1831, 4to. fig. — DESLONGCHAMPS, (EUD.,) Mém. sur le Poecilopleuron Bucklandi, Caen, 1837, 4to. fig. — BRONN, (H. G.,) und KAUP, (J. J.,) Abhandlungen über die Gavialartigen Reptilien, Stuttgart, 1842, fol. fig. — GOLDFUSS, (A.,) Der Schädelbau des Mosasaurus, N. Act. Ac. Nat. Cur., 1844, 4to. fig. — ALTON, (E. D',) und BURMEISTER, (H.,) Der fossile Gavial von Boll, Halle, 1854, fol. fig. — BURMEISTER, (H.,) Die Labyrinthodonten, Berlin, 1850, 4to. fig. — QUENSTEDT, (A.,) Die Mastodonsaurier sind Batrachier, Tübingen, 1850, 4to. fig. — GIBBES, (R. W.,) A Memoir on Mosasaurus and three New Genera, etc., Smithson. Contrib. 1851, 4to. fig. — MEYER, (H. v.,) Zur Fauna der Vorwelt, Die Saurier des Muschelkalkes, etc., Frankfurt a. M., 1845–52, fol. — MEYER, (H. v.,) und PLIENINGER, (TH.,) Beiträge zur Palæontologie Würtembergs, Stuttgart, 1844, 4to. fig. — OWEN, (R.,) Report on British Fossil Reptiles, Brit. Ass. 1839, p. 43; 1841, p. 60. — Fossil Reptilia of the London Clay, (Palæont. Soc.,) London, 1849, 4to. fig. (the Chelonia with T. BELL.) — Fossil Reptilia of the Cretaceous Formation, (Palæont. Soc.,) London, 1851, 4to. fig. — Fossil Reptilia of the Wealden Formation, (Palæont. Soc.,) London, 1852–55, 4to. fig. — LEA, (I.,) On a Fossil Saurian of the New me to make a few more remarks upon this topic. I can, fortunately, be very brief, as we possess a text-book of Palæontology, arranged in zoölogical order, in which every one may at a glance see how, throughout all the classes of the animal kingdom, the different representatives of each, in past ages, are distributed in the successive geological formations.[1] From such a cursory survey, it must appear, that while certain types prevail during some periods, they are entirely foreign to others. This limitation is conspicuous, with reference to entire classes among Vertebrata, while, in other types, it relates more to the orders, or to the families, and extends frequently only to the genera or the species. But, whatever be the extent of their range in time, we shall see presently, that all these types bear, as far as the order of their succession is concerned, the closest relation to the relative rank of living animals of the same types compared with one another, to the phases of the embryonic growth of these types in the present day, and even to their geographical distribution upon the present surface of our globe. I will, however, select

Red Sandstone, etc., Philadelphia, 1852, 4to. fig. — LEIDY, (JOS.,) Description of Extinct Mammalia and Chelonia from Nebraska Territory, in D. D. OWEN, Geol. Surv. of Wisconsin, Iowa, Minesota, etc., Philadelphia, 1852, 4to. fig. — On Bathygnathus borealis, an extinct Saurian, Journ. Ac. Nat. Sc., Philad., 1854, 4to. fig. — Description of a New Species of Crocodile, etc., Ibid., 1851. — *Birds:* OWEN, (R.,) History of British Fossil Mammalia and Birds, London, 1844–46, 1 vol. 8vo. fig. — Fossil Birds from the Wealden, Journ. Geol. Soc., II., p. 96. — Memoir on the Dinornis, Trans. Zool. Soc., vol. 3, p. 3, London, 1844, 4to. fig. — *Mammalia:* CUVIER, (G.,) Oss. foss., q. a. — BUCKLAND, (W.,) Rel. Diluv., q. a., p. 94. — DEBLAINVILLE, (DUCR.,) Ostéographie ou Description iconographique comparée du Squelette, etc., Paris, 1841, et suiv. 4to., Atlas fol. — KAUP, (J. J.,) Descriptions d'ossemens fossiles de Mammifères inconnus, Darmstadt, 1832–39, 4to. fig. — OWEN, (R.,) Odontography, or a Treatise on the Comparative Anatomy of the Teeth, London, 1840–41, 3 vols. 8vo. fig. — Brit. foss. Mam. and Birds, q. a. — The Fossil Mammalia of the Voyage of H. M. S. BEAGLE, London, 1838, 4to. fig. — Description of the Skeleton of an extinct gigantic Sloth, Mylodon robustus, London, 1842, 4to. fig.; and many papers in Journal of Geological Society; Trans. Zool. Society, etc. — SCHMERLING, (P. C.,) Recherches sur les ossemens fossiles des cavernes de Liège, Liège, 1833–36, 2 vols. 4to. fig. — CROIZET et JOBERT, Recherches sur les ossemens fossiles du département du Puy-de-Dôme, Paris, 1828, fol. fig. — MEYER, (H. v.,) Zur Fauna, etc., q. a. — Die fossilen Zähne und Knochen, in der Gegend von Georgensgmünd, Frankfurt a. M., 1834, 4to. fig. — JAEGER, (G. FR.,) Die fossilen Säugethiere Würtembergs, Stuttgardt, 1835–39, fol. fig. — FALCONER, (H.,) and CAUTLEY, (P. T.,) Fauna antiqua sivalensis, etc., London, 1846, fol. fig. — GERVAIS, (P.,) Zoologie et Paléontologie françaises, Paris, 1848–52, 4to. fig. — MÜLLER, (J.,) Ueber die fossilen Reste der Zeuglodonten, etc., Berlin, 1849, fol. fig. — LECONTE, (J.,) On Platygonus compressus, Mem. Amer. Acad. Arts and Sc., 1848, 4to. fig. — WYMAN, (J.,) Notice of the Geological Position of Castoroides ohioensis, by J. HALL, and an Anatomical Description of the same, Boston Journ. Nat. Hist., 1847, vol. 5, p. 385, 8vo. fig. — WARREN, (J. C.,) Description of a Skeleton of the Mastodon giganteus, Boston, 1852, 4to. fol. — LEIDY, (J.,) The Ancient Fauna of Nebraska, Smith. Contr., Washington, 1852, 4to. fig. See also Sect. 22.

[1] I allude to the classical work of PICTET, Traité élémentaire de Paléontologie, q. a., a second edition of which is now publishing.

a few examples for further discussion. Among Echinoderms the Crinoids are, for a long succession of periods, the only representatives of that class; next follow the Starfishes, and next the Sea-Urchins, the oldest of which belong to the type of Cidaris and Echinus, followed by Clypeastroids and Spatangoids. No satisfactory evidence of the existence of Holothuriæ has yet been found. Among Crustacea, a comparison of the splendid work of Barrande[1] upon the Silurian System of Bohemia, with the paper of Count Münster upon the Crustacea of Solenhofen,[2] and with the work of Desmarest upon fossil Crabs,[3] will at once show that while Trilobites are the only Crustacea of the oldest palæozoic rocks, there is found in the jurassic period a carcinological fauna entirely composed of Macrura, to which Brachyura are added in the tertiary period. The formations intermediate between the older palæozoic rocks and the Jura contain the remains of other Entomostraca, and later of some Macroura also. In both classes the succession of their representatives, in different periods, agrees with their respective standing, as determined by the gradation of their structure.

Among plants, we find in the Carboniferous period prominently, Ferns and Lycopodiaceæ;[4] in the Triassic period Equisetaceæ[5] and Coniferæ prevail; in the Jurassic deposits, Cycadeæ,[6] and Monocotyledoneæ; while later only Dicotyledoneæ take the lead.[7] The iconographic illustration of the vegetation of past ages has of late advanced beyond the attempts to represent the characteristic features of the animal world in different geological periods.[8]

Without attempting here to characterize this order of succession, this much follows already from the facts mentioned, that while the material world is ever the same through all ages in all its combinations, as far back as direct investigations can trace its existence, organized beings, on the contrary, transform these same materials into ever new forms and new combinations. The carbonate of lime of all ages is the same carbonate of lime in form as well as composition, as long as it is under the action of physical agents only. Let life be introduced upon earth,

[1] BARRANDE's Syst. Silur., q. a., p. 23.

[2] GR. G. v. MÜNSTER, Beiträge zur Petrefacten-kunde, q. a., p. 98.

[3] DESMAREST, see Brongniart and Desmarest's Hist. Nat. d. Tril. et Crust., q. a., p. 97.

[4] See, above, p. 93.

[5] SCHIMPER, (W. P.,) et MOUGEOT, (A.,) Monographie des Plantes Fossiles du Grès-bigarré de la chaine des Vosges, Strasb. et Paris, 1840–43, 4to. fig.

[6] BUCKLAND, (W.,) On the Cycadeoideæ, a Family of Plants found in the Oolite, etc., Trans. Geol. Soc. Lond. 2d ser. II., p. 395.

[7] UNGER, (FR.,) Chloris protogæa, Beiträge zur Flora der Vorwelt, Leipzig, 1841, 4to. fig.—HEER, (O.,) Flora tertiaria Helvetiæ, Winthurthur, 1855, fol. fig.

[8] Landscapes of the different geological periods are represented in UNGER, (FR.,) Die Vorwelt in ihren vershiedenen Bildungsperioden, Wien, fol. (no date.) These landscapes are ideal representations of the vegetation of past ages.

and a Polyp builds its coral out of it, and each family, each genus, each species a different one, and different ones for all successive geological epochs. Phosphate of lime in palæozoic rocks is the same phosphate, as when prepared artificially by Man; but a Fish makes its spines out of it, and every Fish in its own way, a Turtle its shield, a Bird its wings, a Quadruped its legs, and Man, like all other Vertebrates, its whole skeleton, and during each successive period in the history of our globe, these structures are different for different species. What similarity is there between these facts! Do they not plainly indicate the working of different agencies excluding one another? Truly the noble frame of Man does not owe its origin to the same forces which combine to give a definite shape to the crystal. And what is true of the carbonate of lime, is equally true of all inorganic substances; they present the same characters in all ages past, as those they exhibit now.

Let us look upon the subject in still another light, and we shall see that the same is also true of the influence of all physical causes. Among these agents, the most powerful is certainly electricity; the only one to which, though erroneously, the formation of animals has ever been directly ascribed. The effects it may now produce, it has always produced, and produced them in the same manner. It has reduced metallic ores and various earthy minerals and deposited them in crystalline form, in veins, during all geological ages; it has transported these and other substances from one point to another, in times past, as we may do now in our laboratories, under its influence. Evaporation upon the surface of the earth has always produced clouds in the atmosphere, which after accumulating have been condensed in rain showers in past ages as now. Rain drop marks in the carboniferous and triassic rocks have brought to us this testimony of the identity of the operation of physical agents in past ages, to remind us that what these agents may do now, they already did in the same way, in the oldest geological times, and have done at all times. Who could, in presence of such facts, assume any causal connection between two series of phenomena, the one of which is ever obeying the same laws, while the other presents at every successive period new relations, an ever changing gradation of new combinations, leading to a final climax with the appearance of Man? Who does not see, on the contrary, that this identity of the products of physical agents in all ages, totally disproves any influence on their part in the production of these ever changing beings, which constitute the organic world, and which exhibit, as a whole, such striking evidence of connected thoughts!

SECTION XXII.

LOCALIZATION OF TYPES IN PAST AGES.

The study of the geographical distribution of the animals now living upon earth has taught us, that every species of animals and plants has a fixed home, and even that peculiar types may be circumscribed within definite limits, upon the surface of our globe. But it is only recently, since geological investigations have been carried on in remote parts of the world, that it has been ascertained that this special localization of types extends to past ages. Lund for the first time showed that the extinct Fauna of the Brazils,[1] during the latest period of a past age, consists of different representatives of the very same types now prevalent in that continent; Owen has observed similar relations between the extinct Fauna of Australia[2] and the types now living upon that continent.

If there is any naturalist left who believes that the Fauna of one continent may be derived from another portion of the globe, the study of these facts, in all their bearing, may undeceive him.

It is well known how characteristic the Edentata are for the present Fauna of the Brazils, for there is the home of the Sloths, (Bradypus,) the Tatous, (Dasypus,) the Ant-eaters, (Myrmecophaga); there also have been found those extraordinary extinct genera, the Megatherium, the Mylodon, the Megalonyx, the Glyptodon, and the many other genera described by Dr. Lund and Professor Owen, all of which belong to this same order of Edentata. Some of these extinct genera of Edentata had also representatives in North America, during the same geological period,[3] thus showing that though limited within similar areas, the range of this type has been different in different epochs.

Australia, at present almost exclusively the home of Marsupials, has yielded also a considerable number of equally remarkable species, and two extinct genera of that type, all described by Owen in a report to the British Association, in 1844, and in Michell's Expeditions into the Interior of Australia.

[1] LUND, (DR.,) Blik paa Brasiliens Dyreverden för sidste Jordomvæltning. K. Danske Vidensk. Selsk. Afhandl. VIII., Kiöbenhavn, 1841, 4to. fig., p. 61, etc.; Engl. Abstract, Ann. and Mag. vol. 3, p. 422.

[2] OWEN, (R.,) On the Geographical Distribution of Extinct Mammalia, Ann. and Mag. Nat. Hist., 1846, vol. 17, p. 197.

[3] LEIDY, (JOS.,) A Memoir on the Extinct Sloth Tribe of North America, Smithson. Contrib. 1855, 4to. fig.— WYMAN, (J.,) Notice of Fossil Bones, etc., Am. Journ. Sc. and A., 2d ser., 1850, vol. 10.

How far similar facts are likely to occur in other classes, remains to be ascertained. Our knowledge of the geographical distribution of the fossil remains is yet too fragmentary to furnish any further data upon this point. It is, however, worthy of remark, that though the types of the oldest geological periods had a much wider distribution than most recent families exhibit now, some families of fishes largely represented in the Devonian system of the Old World have not yet been noticed among the fossils of that period in America, as, for instance, the Cephalaspids, the Dipteri, and the Acanthodi. Again, of the many gigantic Reptiles of the Triasic and Oolitic periods, none are known to occur elsewhere except in Europe, and it can hardly be simply owing to the less extensive distribution of these formations in other parts of the world, since other fossils of the same formations are known from other continents. It is more likely that some of them, at least, are peculiar to limited areas of the surface of the globe, as, even in Europe, their distribution is not extensive.

Without, however, entering upon debatable ground, it remains evident, that before the establishment of the present state of things, peculiar types of animals, which were formerly circumscribed within definite limits, have continued to occupy the same or similar grounds in the present period, even though no genetic connection can be assumed between them, their representatives in these different formations not even belonging to the same genera. Such facts are in the most direct contradiction with any assumption that physical agents could have any thing to do with their origin; for though their occurrence within similar geographical areas might at first seem to favor such a view, it must be borne in mind that these so localized beings are associated with other types which have a much wider range, and, what is still more significant, they belong to different geological periods, between which great physical changes have undoubtedly taken place. Thus the facts indicate precisely the reverse of what the theory assumes; they prove a continued similarity of organized beings during successive geological periods, notwithstanding the extensive changes, in the prevailing physical conditions, which the country they inhabited may have undergone, at different periods. In whatever direction this theory of the origin of animals and plants, under the influence of physical agents, is approached, it can nowhere stand a critical examination. Only the deliberate intervention of an Intellect, acting consecutively, according to one plan, can account for phenomena of this kind.

SECTION XXIII.

LIMITATION OF SPECIES TO PARTICULAR GEOLOGICAL PERIODS.

Without entering into a discussion respecting the precise limits within which this fact is true, there can no longer be any doubt, that not only species, but all other groups of animals and plants, have a definite range of duration, as well as individuals.[1] The limits of this duration, as far as species are concerned, generally coincide with great changes in the physical conditions of the earth's surface;[2] though, strange to say, most of those investigators who would ascribe the origin of organized beings to the influence of such causes, maintain also, that species may extend from one period to another, which implies that these are not affected by such changes.[3]

When considering, in general, the limitation of species to particular geological periods, we might very properly disregard the question of the simultaneity of the successive appearance and disappearance of Faunæ, as in no way affecting the result of the investigation, as long as it is universally conceded, that there is no species, known among the fossils, which extends through an indefinite series of geological formations. Moreover, the number of the species, still considered as identical in several successive periods, is growing smaller and smaller, in proportion as they are more closely compared. I have already shown, long ago, how widely many of the tertiary species, long considered as identical with living ones, differ from them,[4] and also how different the species of the same family may be, in successive subdivisions of the same great geological formation.[5] Hall has come to the same result in his investigations of the fossils of the State of New York.[6] Every monograph reduces their number, in every formation. Thus Barrande, who has devoted so many years to the most minute investigation of the Trilobites of

[1] Compare Sect. XIX.

[2] ELIE DE BEAUMONT, Recherches sur quelques-unes des Révolutions de la surface du Globe, Paris, 1830, 1 vol. 8vo.

[3] For indications respecting the occurrence of all species of fossil organized beings now known, consult, BRONN, (H. G.) Index palæontologicus, Stuttgardt, 1848–49, 3 vols. 8vo. — ORBIGNY, (A. D',) Prodrome de Paléontologie stratigraphique universelle etc., Paris, 1850, 2 vols. 12mo. — MORRIS, (J.,) Catalogue of the British Fossils, London, 1854, 1 vol. 8vo.

[4] AGASSIZ, (L.,) Coquilles tertiaires reputées identiques avec les espèces vivantes, Neuchâtel, 1845, 4to. fig.

[5] AGASSIZ, (L.,) Etudes critiques sur les Mollusques fossiles, Neuchâtel, 1840–45, 4to. fig.

[6] HALL, (J.,) Palæontology of the State of New York, q. a., p. 23, note 1.

Bohemia,[1] has come to the conclusion that their species do not extend from one formation to the other; D'Orbigny[2] and Pictet[3] have come to the same conclusion for the fossil remains of all classes. It may well be said that, as fossil remains are studied more carefully, in a zoölogical point of view, the supposed identity of species, in different geological formations, vanishes gradually more and more; so that the limitation of species in time, already ascertained in a general way, by the earlier investigations of their remains in successive geological formations, is circumscribed, step by step, within narrower, more definite, and also more equable periods. Species are truly limited in time, as they are limited in space, upon the surface of the globe. The facts do not exhibit a gradual disappearance of a limited number of species, and an equally gradual introduction of an equally limited number of new ones; but, on the contrary, the simultaneous creation and the simultaneous destruction of entire faunæ, and a coincidence between these changes in the organic world and the great physical changes our earth has undergone. Yet it would be premature to attempt to determine the extent of the geographical range of these changes, and still more questionable to assert their synchronism upon the whole surface of the globe, in the ocean and upon dry land.

To form adequate ideas of the great physical changes the surface of our globe has undergone, and the frequency of these modifications of the character of the earth's surface, and of their coincidence with the changes observed among the organized beings, it is necessary to study attentively the works of Elie de Beaumont.[4] He, for the first time, attempted to determine the relative age of the different systems of mountains, and showed first, also, that the physical disturbances occasioned by their upheaval coincided with the successive disappearance of entire faunæ, and the reappearance of new ones. In his earlier papers he recognized seven, then twelve, afterwards fifteen such great convulsions of the globe, and now he has traced more or less fully and conclusively the evidence that the number of these disturbances has been at least sixty, perhaps one hundred. But while the genesis and genealogy of our mountain systems were thus illustrated, palæontologists, extending their comparisons between the fossils of different formations more carefully to all the successive beds of each great era, have observed more and more marked differences between them, and satisfied themselves that faunæ also have been more frequently renovated, than was formerly supposed; so that the general results of

[1] BARRANDE, Système silurien, etc., q. a.; see, also, my Monographies d'Echinodermes, q. a., p. 54.

[2] D'ORBIGNY, Paléontologie Française, q. a., p. 95.

[3] PICTET, Traité de Paléontologie, etc., q. a., p. 96, note 1.

[4] ELIE DE BEAUMONT, Notice sur les systèmes de Montagnes, Paris, 1852, 3 vols. 12mo.; see, also, BUCH, (LEOP. v.) Ueber die geognotischen Systeme von Deutschland, Leonhard's Taschenb., 1824, II., p. 501.

geology proper and of palæontology concur in the main to prove, that while the globe has been at repeated intervals, and indeed frequently, though after immensely long periods, altered and altered again, until it has assumed its present condition, so have also animals and plants, living upon its surface, been again and again extinguished and replaced by others, until those now living were called into existence with man at their head. The investigation is not in every case sufficiently complete to show everywhere a coincidence between this renovation of animals and plants and the great physical revolutions which have altered the general aspect of the globe, but it is already extensive enough to exhibit a frequent synchronism and correlation, and to warrant the expectation that it will, in the end, lead to a complete demonstration of their mutual dependence, not as cause and effect, but as steps in the same progressive development of a plan which embraces the physical as well as the organic world.

In order not to misapprehend the facts, and perhaps to fall back upon the idea, that these changes may be the cause of the differences observed between the fossils of different periods, it must be well understood that, while organized beings exhibit through all geological formations a regular order of succession, the character of which will be more fully illustrated hereafter, this succession has been from time to time violently interrupted by physical disturbances, without any of these altering in any way the progressive character of that succession of organized beings. Truly this shows that the important, the leading feature of this whole drama is the development of life,[1] and that the material world affords only the elements for its realization. The simultaneous disappearance of entire faunæ, and the following simultaneous appearance of other faunæ, show further that, as all these faunæ consist of the greatest variety of types,[2] in all formations, combined everywhere into natural associations of animals and plants, between which there have been definite relations at all times, their origin can at no time be owing to the limited influence of monotonous physical causes, ever acting in the same way. Here, again, the intervention of a Creator is displayed in the most striking manner, in every stage of the history of the world.

[1] DANA, (J. D.,) Address, q. a., p. 94, note 1. [2] AGASSIZ, (L.,) Geol. Times, q. a., p. 25.

SECTION XXIV.

PARALLELISM BETWEEN THE GEOLOGICAL SUCCESSION OF ANIMALS AND PLANTS AND THEIR PRESENT RELATIVE STANDING.

The total absence of the highest representatives of the animal kingdom in the oldest deposits forming part of the crust of our globe, has naturally led to the very general belief, that the animals which have existed during the earliest period of the history of our earth were inferior to those now living, nay, that there is a natural gradation from the oldest and lowest animals to the highest now in existence.[1] To some extent this is true; but it is certainly not true that all animals form one simple series from the earliest times, during which only the lowest types of animals would have been represented, to the last period, when Man appeared at the head of the animal creation.[2] It has already been shown (Sect. VII.) that representatives of all the great types of the animal kingdom have existed from the beginning of the creation of organized beings. It is therefore not in the successive appearance of the great branches of the animal kingdom, that we may expect to trace a parallelism between their succession in geological times and their relative standing at present. Nor can any such correspondence be observed between the appearance of classes, at least not among Radiata, Mollusks, and Articulata, as their respective classes seem to have been introduced simultaneously upon our earth, with perhaps the sole exception of the Insects, which are not known to have existed before the Carboniferous period. Among Vertebrata, however, there appears already a certain coincidence, even within the limits of the classes, between the time of their introduction, and the rank their representatives hold, in comparison to one another. But upon this point more hereafter.

It is only within the limits of the different orders of each class, that the parallelism between the succession of their representatives in past ages and their respective rank, in the present period, is decidedly characteristic. But if this is true, it must be at the same time obvious to what extent the recognition of this correspondence may be influenced by the state of our knowledge of the true affinities and natural gradation of living animals, and that until our classifications have become the correct expression of these natural relations, even the most striking coincidence with the succession of their representatives in past ages may be entirely overlooked. On that account it would be presumptuous on my part to pretend, that I could

[1] See the palæontological works quoted in Sect. 21. [2] AGASSIZ, (L.) Twelve Lect., etc., p. 25 and 69.

illustrate this proposition, through the whole animal kingdom, as such an attempt would involve the assertion that I know all these relations, or that where there exists a discrepancy between the classification and the succession of animals, the classification must be incorrect, or the relationship of the fossils incorrectly appreciated. I shall therefore limit myself here to a general comparison, which may, however, be sufficient to show, that the improvements which have been introduced in our systems, upon purely zoölogical grounds, have nevertheless tended to render more apparent the coincidence between the relative standing among living animals and the order of succession of their representatives in past ages. I have lately attempted to show, that the order of Halcyonoids, among Polyps, is superior to that of Actinoids;[1] that, in this class, compound communities constitute a higher degree of development, when contrasted with the characters and mode of existence of single Polyps, as exhibited by the Actinia; that top-budding is superior to lateral budding; and that the type of Madrepores, with their top-animal, or at least with a definite and limited number of tentacles, is superior to all other Actinoids. If this be so, the prevalence of Actinoids in older geological formations, to the exclusion of Halcyonoids, the prevalence of *Rugosa* and *Tabulata* in the oldest deposits,[2] the later prevalence of Astræoids, and the very late introduction of Madrepores, would already exhibit a correspondence between the rank of the living Polyps and the representatives of that class in past ages, though we may hardly expect a very close coincidence in this respect between animals the structure of which is so simple.

The gradation among the orders of Echinoderms is perfectly plain. Lowest stand the Crinoids, next the Asterioids, next the Echinoids, and highest the Holothurioids. Ever since this class has been circumscribed within its natural limits, this succession has been considered as expressing their natural relative standing, and modern investigations respecting their anatomy and embryology, however extensive, have not led to any important change in their classification, as far as the estimation of their rank is concerned. This is also precisely the order in which the representatives of this class have successively been introduced upon earth in past geological ages. Among the oldest formations we find pedunculated Cinoids[3] only, and this order remains prominent for a long series of successive periods; next come free Crinoids and Asterioids; next Echinoids,[4] the successive appearance of which since the triasic

[1] For classification of Polypi, see DANA, q. a., p. 31, note 2; also MILNE-EDWARDS and HAIME, q. a., and AGASSIZ, (L.,) Classification of Polyps, Proc. Am. Acad. Sc. and Arts, 1856, p. 187.

[2] See MILNE-EDWARDS and HAIME, q. a., p. 31.

[3] MILLER, Crinoids, q. a. — D'ORBIGNY, q. a. — J. HALL, q. a. — AUSTIN, q. a., p. 96.

[4] See the works q. a., p. 96; also: MÜLLER, (J.,) and TROSCHEL, (F. H.,) System der Asteriden, Braunschweig, 1842, 4to. fig. — MÜLLER, (J.,) Ueber den Bau der Echinodermen, Berlin, 1854. 4to. — TIEDEMAN, (FR.,) Anatomie der Röhren-Holothurie, des Seeigels, etc., Landshut, 1817, fol. fig. — VALENTIN, (G.,) Anat. du genre Echinus, Neuchâtel, 1842. 4to.

period to the present day, coincides also with the gradation of their subdivisions, as determined by their structure; and it was not until the present period, that the highest Echinoderms, the Holothurioids, have assumed a prominent position in their class.

Among Acephala there is not any more uncertainty respecting the relative rank of their living representatives, than among Echinoderms. Every zoölogist acknowledges the inferiority of the Bryozoa and the Brachiopods[1] when compared with the Lamellibranchiata, and among these the inferiority of the Monomyaria in comparison with the Dimyaria would hardly be denied. Now if any fact is well established in Palæontology, it is the earlier appearance and prevalence of Bryozoa and Brachiopods in the oldest geological formations, and their extraordinary development for a long succession of ages, until Lamellibranchiata assume the ascendency which they maintain to the fullest extent at present. A closer comparison of the different families of these orders might further show how close this correspondence is through all ages.

Of Gasteropoda I have nothing special to say, as every palæontologist is aware how imperfectly their remains have been investigated in comparison with what has been done for the fossils of other classes. Yet the Pulmonata are known to be of more recent origin than the Branchifera, and among these the Siphonostomata to have appeared later than the Holostomata, and this exhibits already a general coincidence between their succession in time and their respective rank.

Our present knowledge of the anatomy of the Nautilus, for which science is indebted to the skill of Owen,[2] may satisfy everybody that among Cephalopods the Tetrabranchiata are inferior to the Dibranchiata; and it is not too much to say, that one of the first points a collector of fossils may ascertain for himself, is the exclusive prevalence of the representatives of the first of these types in the oldest formations, and the later appearance, about the middle geological ages, of representatives of the other type, which at present is the most widely distributed.

Of Worms, nothing can be said of importance with reference to our inquiry;

[1] ORBIGNY, (A. D',) Bryozoires, Ann. Sc. Nat., 3e sér. 1851, vol. 16, p. 292.—CUVIER, (G.,) Mémoire sur l'animal de la Lingule, Ann. Mus. I., p. 69, fig.—VOGT, (C.,) Anatomie der Lingula anatina, N. Mém. Soc. Helv. 1843, VII., 4to. fig.—OWEN, (R.,) On the Anatomy of the Brachiopoda, Trans. Zool. Soc., I. 4to., p. 145, fig.—On the Anatomy of the Terebratula, 1853, 4to. fig. (Palæont. Soc.)—BUCH, (L. v.,) Ueber Terebrateln, q. a., p. 97.—DAVIDSON, (TH.,) Monogr. etc., q. a., p. 97.—POLI (XAV.,) Testacea utriusque Siciliæ, eorumque Historia et Anatomia, Parmæ, 1791–93, 2 vols. fol. fig., continued by Delle Chiaje.

[2] OWEN, (R.,) Memoir on the Pearly Nautilus, London, 1832, 4to. fig.—VALENCIENNES, (A.,) Nouvelles Recherches anatomiques sur le Nautile. C. R., Paris, 1841, 4to.—CUVIER, (G.,) Mémoires pour servir à l'Histoire et à l'Anatomie des Mollusques, Paris, 1817, 4to. fig.—EDWARDS, (H. M.,) QUATREFAGES, (AR. DE,) et BLANCHARD, (EM.) Voyage en Sicile, Paris, 3 vols. 4to. fig. (without date.)

but the Crustacea exhibit, again, the most striking coincidence. Without entering into details, it appears from the classification of Milne-Edwards that Decapods, Stomapods, Amphipods, and Isopods constitute the higher orders, while Branchiopods, Entomostraca, Trilobites, and the parasitic types, constitute, with Limulus, the lower orders of this class.[1] In the classification of Dana,[2] his first type embraces Decapods and Stomapods, the second Amphipods and Isopods, the third Entomostraca, including Branchiopods, the fourth Cirripedia, and the fifth Rotatoria. Both acknowledge in the main the same gradation; though they differ greatly in the combination of the leading groups, and also the exclusion by Milne-Edwards of some types, as the Rotifera, which Burmeister first, then Dana and Leydig, unite justly, as I believe, with the Crustacea.[3] This gradation now presents the most perfect coincidence with the order of succession of Crustacea in past geological ages, even down to their subdivisions into minor groups. Trilobites and Entomostraca are the only representatives of the class in palæozoic rocks; in the middle geological ages appear a variety of Shrimb, among which the Macrouran Decapods are prominent, and later only the Brachyoura, which are the most numerous in our days.

The fragmentary knowledge we possess of the fossil Insects, does not justify us, yet, in expecting to ascertain with any degree of precision, the character of their succession through all geological formations, though much valuable information has already been obtained respecting the entomological faunæ of several geological periods.[4]

The order of succession of Vertebrata in past ages, exhibits features in many respects differing greatly from the Articulata, Mollusks, and Radiata. Among these we find their respective classes appearing simultaneously in the oldest periods of the history of our earth. Not so with the Vertebrata, for though Fishes may be as old as any of the lower classes, Reptiles, Birds, and Mammalia are introduced successively in the order of their relative rank in their type. Again, the earliest representatives of these classes do not always seem to be the lowest; on the contrary, they are to a certain extent, and in a certain sense, the highest, in as far as they embody characters, which, in later periods, appear separately in higher classes, (See Sect. 26,) to the exclusion of what henceforth constitutes the special character of the lower class. For instance, the oldest Fishes known partake of the characters, which, at a later time, are exclusively found in Reptiles, and no longer belong to the Fishes of the present day. It may be said, that the earliest Fishes are rather the oldest representatives of the type of Vertebrata than of the

[1] MILNE-EDWARDS, Hist. Nat. des Crustacés, Paris, 1834–40, 3 vols. 8vo.

[2] DANA, (J. D.,) Crustacea, q. a., p. 32.

[3] LEYDIG, (FR.,) Räderthiere, etc., Zeitsch. f. wiss. Zool. 1854, vol. 6, p. 1.

[4] HEER, q. a.; BRODIE, q. a., p. 98.

class of Fishes, and that this class assumes only its proper characters after the introduction of the class of Reptiles upon earth. Similar relations may be traced between the Reptiles and the classes of Birds and Mammalia, which they precede. I need only allude here to the resemblance of the Pterodactyli and the Birds, and to that of Ichthyosauri and certain Cetacea. Yet, through all these intricate relations, there runs an evident tendency towards the production of higher and higher types, until at last, Man crowns the whole series. Seen as it were at a distance, so that the mind can take a general survey of the whole, and perceive the connection of the successive steps, without being bewildered by the details, such a series appears like the development of a great conception, expressed in such harmonious proportions, that every link appears necessary to the full comprehension of its meaning, and yet, so independent and perfect in itself, that it might be mistaken for a complete whole, and again, so intimately connected with the preceding and following members of the series, that one might be viewed as flowing out of the other. What is universally acknowledged as characteristic of the highest conceptions of genius, is here displayed in a fulness, a richness, a magnificence, an amplitude, a perfection of details, a complication of relations, which baffle our skill and our most persevering efforts to appreciate all its beauties. Who can look upon such series, coinciding to such an extent, and not read in them the successive manifestations of a thought, expressed at different times, in ever new forms, and yet tending to the same end, onwards to the coming of Man, whose advent is already prophesied in the first appearance of the earliest Fishes!

The relative standing of plants presents a somewhat different character from that of animals. Their great types are not built upon so strictly different plans of structure; they exhibit, therefore, a more uniform gradation from their lowest to their highest types, which are not personified in one highest plant, as the highest animals are in Man.

Again, Zoölogy is more advanced respecting the limitation of the most comprehensive general divisions, than Botany, while Botany is in advance respecting the limitation and characteristics of families and genera. There is, on that account, more diversity of opinion among botanists respecting the number, and the relative rank of the primary divisions of the vegetable kingdom, than among zoölogists respecting the great branches of the animal kingdom. While most writers[1] agree in admitting among plants, such primary groups as Acotyledones, Monocotyledones, and Dicotyledones, under these or other names, others would separate the Gymnosperms from the Dicotyledones.[2]

It appears to me, that this point in the classification of the living plants cannot

[1] GÖPPERT, etc., q. a., p. 93.

[2] AD. BRONGNIART, etc., q. a., p. 93.

be fully understood without a thorough acquaintance with the fossils and their distribution in the successive geological formations, and that this case exhibits one of the most striking examples of the influence classification may have upon our appreciation of the gradation of organized beings in the course of time. As long as Gymnosperms stand among Dicotyledones, no relation can be traced between the relative standing of living plants and the order of succession of their representatives in past ages. On the contrary, let the true affinity of Gymnosperms with Ferns, Equisetaceæ, and especially with Lycopodiaceæ be fully appreciated, and at once we see how the vegetable kingdom has been successively introduced upon earth, in an order which coincides with the relative position its primary divisions bear to one another, in respect to their rank, as determined by the complication of their structure. Truly, the Gymnosperms, with their imperfect flower, their open carpels, supporting their polyembryonic seeds in their axis, are more nearly allied to the anathic Acrophytes, with their innumerable spores, than to either the Monocotyledones or Dicotyledones; and, if the vegetable kingdom constitutes a graduated series beginning with Cryptoganes, followed by Gymnosperms, and ending with Monocotyledones and Dicotyledones, have we not in that series the most striking coincidence with the order of succession of Cryptogams in the oldest geological formations, especially with the Ferns, Equisetaceæ, and Lycopodiaceæ of the Carboniferous period, followed by the Gymnosperms of the Trias and Jura and the Monocotyledones of the same formation and the late development of Dicotyledones? Here, as everywhere, there is but one order, one plan in nature.

SECTION XXV.

PARALLELISM BETWEEN THE GEOLOGICAL SUCCESSION OF ANIMALS AND THE EMBRYONIC GROWTH OF THEIR LIVING REPRESENTATIVES.

Several authors have already alluded to the resemblance which exists between the young of some of the animals now living, and the fossil representatives of the same families in earlier periods.[1] But these comparisons have, thus far, been traced only in isolated cases, and have not yet led to a conviction, that the character of the succession of organized beings in past ages, is such, in general, as to show

[1] AGASSIZ, (L.,) Poiss. foss., q. a., p. 54. — Embryonic Types, q. a., p. 11. — Twelve Lect., etc., p. 8. — EDWARDS, (H. MILNE,) Considérations sur quelques principes relatifs à la Classification naturelle des animaux, An. Sc. Nat., 3e sér., 1844, 1 vol. p. 65.

a remarkable agreement with the embryonic growth of animals; though the state of our knowledge in Embryology and Palæontology justifies now such a conclusion. The facts most important to a proper appreciation of this point, have already been considered in the preceding paragraph, as far as they relate to the order of succession of animals, when compared with the relative rank of their living representatives. In examining now the agreement between this succession and the phases of the embryonic growth of living animals, we may, therefore, take for granted, that the order of succession of their fossil representatives is sufficiently present to the mind of the reader, to afford a satisfactory basis of comparison. Too few Corals have been studied embryologically, to afford extensive means of comparison; yet so much is known, that the young polyp, when hatched, is an independent, simple animal, that it is afterwards incased in a cup, secreted by the foot of the actinoid embryo, which may be compared to the external wall of the *Rugosa*,[1] and that the polyp gradually widens until it has reached its maximum diameter, prior to budding or dividing, while in ancient corals this stage of enlargement seems to last during their whole life, as, for example, in the Cyathophylloids. None of the ancient Corals form those large communities, composed of myriads of united individuals, so characteristic of our coral reefs; the more isolated and more independent character of the individual polyps of past ages presents a striking resemblance to the isolation of young corals, in all the living types. In no class is there, however, so much to learn still, as in Polypi, before the correspondence of their embryonic growth, and their succession in time, can be fully appreciated. In this connection I would also remark, that among the lower animals, it is rarely observed, that any one, even the highest type, represents in its metamorphoses all the stages of the lower types, neither in their development, nor in the order of their succession; and that frequently the knowledge of the embryology of several types of different standing, is required, to ascertain the connection of the whole series in both spheres.

No class affords, as yet, a more complete and more beautiful evidence of the correspondence of their embryonic changes, with the successive appearance of their representatives in past ages, than the Echinoderms, thanks to the extensive and patient investigations of J. Müller upon the metamorphoses of these animals.[2] Prior to the publication of his papers, the metamorphosis of the European Comatula alone was known. (See Sect. XVIII., p. 85.) This had already shown, that the early stages of growth of this Echinoderm exemplify the peduncated Crinoids of past ages. I have myself seen further, that the successive stages of the embryonic growth of Comatula typify, as it were, the principal forms of Crinoids which characterize the successive

[1] MILNE-EDWARDS et HAIME, q. a., p. 31.

[2] MÜLLER, (J.,) Seven papers, q. a., p. 71.

geological formations; first, it recalls the Cistoids of the palæozoic rocks, which are represented in its simple sphæroidal head, next the few-plated Platycrinoids of the Carboniferous period, next the Pentacrinoids of the Lias and Oolithe, with their whorls of cirrhi, and finally, when freed from its stem, it stands as the highest Crinoid, as the prominent type of the family, in the present period. The investigations of Müller upon the larvæ of all the families of living Asterioids and Echinoids enable us to extend these comparisons to the higher Echinoderms also. The first point which strikes the observers in the facts ascertained by Müller, is the extraordinary similarity of so many larvæ, of such different orders and different families as the Ophiuroids and Asterioids, the Echinoids proper and the Spatangoids, and even the Holothurioids, all of which end, of course, in reproducing their typical peculiarities. It is next very remarkable, that the more advanced larval state of Echinoids and Spatangoids should continue to show such great similarity, that a young Amphidetus hardly differs from a young Echinus.[1] Finally, not to extend these remarks too far, I would only add, that these young Echinoids (Spatangus, as well as Echinus proper) have rather a general resemblance to Cidaris, on account of their large spines, than to Echinus proper. Now, these facts agree exactly with what is known of the successive appearance of Echinoids in past ages;[2] their earliest representatives belong to the genera Diadema and Cidaris, next come true Echinoids, later only Spatangoids. When the embryology of the Clypeastroids is known, it will, no doubt, afford other links to connect a larger number of the members of this series.

What is known of the embryology of Acephala, Gasteropoda, and Cephalopoda, affords but a few data for such comparisons. It is, nevertheless, worthy of remark, that while the young *Lamellibranchiata* are still in their embryonic stage of growth, they resemble, externally at least, Brachiopods[3] more than their own parents, and the young shells of all Gasteropods[4] known in their embryonic stage of growth, being all holostomate, recall the oldest types of that class. Unfortunately, nothing is yet known of the embryology of the Chambered Cephalopoda, which are the only ones found in the older geological formations, and the changes which the shield of the Dibranchiata undergoes have not yet been observed, so that no comparisons can be established between them and the Belemnites and other representatives of this order in the middle and more recent geological ages.

Respecting Worms, our knowledge of the fossils is too fragmentary to lead to any conclusion, even should our information of the embryology of these animals

[1] Compare J. Müller's 1st paper, pl. III., with pls. IV.–VII., and with pls. VI. and VII., 4th paper.

[2] AGASSIZ, (L.,) Twelve Lectures, q. a., etc. p. 25.

[3] See the works, q. a., p. 73, note 1.

[4] See the works, q. a., p. 73, note 2, especially those relating to Nudibranchiata.

be sufficient as a basis for similar comparisons. The class of Crustacea, on the contrary, is very instructive in this respect; but, to trace our comparisons through the whole series, it is necessary that we should consider simultaneously the embryonic growth of the higher Entomostraca, such as Limulus, and that of the highest order of the class,[1] when it will appear, that as the former recall in early life the form and character of the Trilobites, so does the young Crab passing through the form of the Isopods, and that of the Macrouran Decapods, before it assumes its typical form as Brachyouran, recall the well-known succession of Crustacea through the geological middle ages and the tertiary periods to the present day. The early appearance of Scorpions, in the Carboniferous period, is probably also a fact to the point, if, as I have attempted to show, Arachnidians may be considered as exemplifying the chrysalis stage of development of Insects;[2] but, for reasons already stated (Sect. XXIV.) it is hardly possible to take Insects into consideration in these inquiries.

In my researches upon fossil Fishes,[3] I have pointed out at length the embryonic character of the oldest fishes, but much remains to be done in that direction. The only fact of importance I have learned of late, is that the young Lepidosteus, long after it has been hatched, exhibits in the form of its tail, characters, thus far only known among the fossil fishes of the Devonian system.[4] It is to be hoped, that the embryology of the Crocodile will throw some light upon the succession of the gigantic Reptiles of the middle geological ages, as I shall show, that the embryology of Turtles throws light upon the fossil Chelonians. It is already plain, that the embryonic changes of Batrachians coincide with what is known of their succession in past ages.[5] The fossil Birds are too little known, and the fossil Mammalia[6] do not extend through a sufficiently long series of geological formations to afford many striking points of comparison; yet, the characteristic peculiarities of their extinct genera exhibit everywhere indications, that their living representatives in early life resemble them more than they do their own parents. A minute comparison of a young elephant, with any mastodon, will show this most fully, not only in the peculiarities of their teeth, but even in the proportion of their limbs, their toes, etc.

It may, therefore, be considered as a general fact, very likely to be more fully illustrated as investigations cover a wider ground, that the phases of development of all living animals correspond to the order of succession of their extinct representatives in past geological times. As far as this goes, the oldest representatives

[1] AGASSIZ, (L.) Twelve Lectures, etc., p. 66.

[2] Classif. of Insects, q. a., p. 85.

[3] Poiss. fossiles, q. a., p. 54.

[4] AGASSIZ, (L.) Lake Superior, etc., p. 254.

[5] See the works, q. a., p. 82, note 3.

[6] CUV., Oss. foss., q. a.: also, AGASSIZ, (L.) Zoölogical Character of Young Mammalia, Proc. Am. Ass. Adv. Sc., Cambridge, 1849, p. 85.

of every class may then be considered as embryonic types of their respective orders or families among the living. Pedunculated Crinoids are embryonic types of the Comatuloids, the oldest Echinoids embryonic representatives of the higher living families, Trilobites embryonic types of Entomostraca, the Oolitic Decapods embryonic types of our Crabs, the Heterocercal Ganoids embryonic types of the Lepidosteus, the Andrias Scheuchzeri an embryonic prototype of our Batrachians, the Zeuglodonts embryonic Sirenidæ, the Mastodonts embryonic Elephants, etc.

To appreciate, however, fully and correctly all these relations, it is further necessary to make a distinction between embryonic types in general, which represent in their whole organization early stages of growth of higher representatives of the same type, and *embryonic features* prevailing more or less extensively in the characters of allied genera, as in the case of the Mastodon and Elephant, and what I would call *hypembryonic types*, in which embryonic features are developed to extremes in the further periods of growth, as, for instance, the wings of the Bats, which exhibit the embryonic character of a webbed hand, as all Mammalia have it at first, but here grown out and developed into an organ of flight, or assuming in other families the shape of a fin, as in the Whale, or the Sea-turtle, in which the close connection of the fingers is carried out to another extreme.

Without entering into further details upon this subject, which will be fully illustrated in this work, enough has already been said to show, that the leading thought which runs through the succession of all organized beings in past ages, is manifested again in new combinations, in the phases of the development of the living representatives of these different types. It exhibits everywhere the working of the same creative Mind, through all times, and upon the whole surface of the globe.

SECTION XXVI.

PROPHETIC TYPES AMONG ANIMALS.

We have seen in the preceding paragraph, how the embryonic conditions of higher representatives of certain types, called into existence at a later time, are typified, as it were, in representatives of the same types, which have existed at an earlier period. These relations, now they are satisfactorily known, may also be considered as exemplifying, as it were, in the diversity of animals of an earlier period, the pattern upon which the phases of the development of other animals of a later period were to be established. They appear now, like a prophecy in those earlier times, of an order of things not possible with the earlier combinations then prevailing in the animal kingdom, but exhibiting in a later period, in a striking manner, the antecedent considerations of every step in the gradation of animals.

This is, however, by no means the only, nor even the most remarkable case, of such prophetic connections between facts of different dates.

Recent investigations in Palæontology have led to the discovery of relations between animals of past ages and those now living, which were not even suspected by the founders of that science. It has, for instance, been noticed, that certain types which are frequently prominent among the representatives of past ages, combine in their structure, peculiarities which at later periods are only observed separately in different, distinct types. Sauriod Fishes before Reptiles, Pterodactyles before Birds, Ichthyosauri before Dolphins, etc.

There are entire families, among the representatives of older periods, of nearly every class of animals, which, in the state of their perfect development exemplify such prophetic relations, and afford, within the limits of the animal kingdom, at least, the most unexpected evidence, that the plan of the whole creation had been maturely considered long before it was executed. Such types, I have for some time past, been in the habit of calling *prophetic types*. The Sauroid[1] Fishes of the past geological ages, are an example of this kind. These Fishes, which have preceded the appearance of Reptiles, present a combination of ichthyic and reptilian characters, not to be found in the true members of this class, which form its bulk at present. The Pterodactyles[2] which have preceded the class of Birds, and the Ichthyosauri[3] which have preceded the appearance of the Crustacea, are other examples of such prophetic types. These cases suffice for the present, to show that there is a real difference between *embryonic* types and *prophetic* types. Embryonic types are in a measure also prophetic types, but they exemplify only the peculiarities of development of the higher representatives of their own types; while prophetic types exemplify structural combinations observed at a later period, in two or several distinct types, and are, moreover, not necessarily embryonic in their character, as for example, the Monkeys in comparison to Man; while they may be so, as in the case of the Pinnate, Plantigrade, and Digitigrade Carnivora, or still more so in the case of the pedunculated Crinoids.[4]

Another combination is also frequently observed among animals, when a series exhibits such a succession as exemplifies a natural gradation, without immediate

[1] AGASSIZ, (L.) Poiss. foss., vol. 2, part 2.

[2] CUVIER, (G.) Oss. foss., vol. 5, p. 2.

[3] CUVIER, (G.) Oss. foss., as q. a.

[4] See above, Sect. 25.

or necessary reference to either embryonic development or succession in time, as the Chambered Cephalopods. Such types I call *progressive types.*[1]

Again, a distinction ought to be made between prophetic types proper and what I would call *synthetic types,* though both are more or less blended in nature. Prophetic types proper, are those which in their structural complications lean towards other combinations fully realized in a later period, while synthetic types, are those which combine, in a well balanced measure, features of several types occurring as distinct, only at a later time. Sauroid Fishes and Ichthyosauri are more distinctly synthetic than prophetic types, while Pterodactyles have more the character of prophetic types; so are also Echinocrinus with reference to Echini, Pentremites with reference to Asterioids, and Pentacrinus with reference to Comatula. Full illustrations of these different cases will yet be needed to render obvious the importance of such comparisons, and I shall not fail, in the course of this work, to present ample details upon this subject. Enough, however, has already been said to show, that the character of these relations among animals of past ages, compared with those of later periods or of the present day, exhibits more strikingly than any other feature of the animal kingdom, the thoughtful connection which unites all living beings, through all ages, into one great system, intimately linked together from beginning to end.

SECTION XXVII.

PARALLELISM BETWEEN THE STRUCTURAL GRADATION OF ANIMALS AND THEIR EMBRYONIC GROWTH.

So striking is the resemblance of the young of higher animals to the full-grown individuals of lower types, that it has been assumed by many writers that all the higher animals pass, during the earlier stages of their growth, through phases corresponding to the permanent constitution of the lower classes. These suppositions, the results of incomplete investigations, have even become the foundation of a system of philosophy of Nature, which represents all animals as the different degrees of development of a few primitive types.[2] These views have been too generally circulated of late, in an anonymous work, entitled "Vestiges of Creation," to require

[1] AGASSIZ, (L.,) On the Difference between Progressive, Embryonic, and Prophetic Types, etc., Proc. Am. Ass. Adv. Sc., Cambridge, 1849, p. 432.

[2] LAMARCK, q. a., p. 26. — DUMAILLET, (Pseudon. TELLIAMED,) Entretiens d'un Philosophe indien avec un missionaire français, Amsterdam, 1748, 2 vols. 8vo. — OKEN, (LOR.,) Lehrbuch der Natur-Philosophie, q. a., p. 18. — The Vestiges of Creation, etc.

further mention here. It has also been shown above (Sect. VIII.) that animals do not form such a simple series as would result from a successive development. There remains, therefore, only for us to show now within what limits the natural gradation which may be traced in the different types of the animal kingdom,[1] corresponds to the changes they undergo during their growth, having already considered the relations which exist between these metamorphoses and the successive appearance of animals upon earth, and between the latter and the structural gradation or relative standing of their living representatives. Our knowledge of the complication of structure of all animals is sufficiently advanced to enable us to select, almost at random, our examples of the correspondence between the structural gradation of animals and their embryonic growth, in all those classes the embryologic development of which has been sufficiently investigated. Yet, in order to show more distinctly how closely all the leading features of the animal kingdom are combined, whether we consider the complication of their structure, or their succession in time, or their embryonic development, I shall refer by preference to the same types which I have chosen before for the illustration of the other relations.

Among Echinoderms, we find in the order of Crinoids the pedunculated types standing lowest,[2] Comatulæ highest, and it is well known that the young Comatula is a pedunculated Crinoid, which only becomes free in later life.[3] J. Müller has shown that among the Echinoids, even the highest representatives, the Spatangoids, differ but slightly in early youth from the Echinoids, and no zoölogist can doubt that these are inferior to the former. Among Crustacea, Dana[4] has insisted particularly upon the serial gradation which may be traced between the different types of Decapods, their order being naturally from the highest Brachyoura, through the Anomoura, the Macroura, the Tetradecapods, etc., to the Entomostraca; the Macrouran character of the embryo of our Crabs has been fully illustrated by Rathke,[5] in his beautiful investigations upon the embryology of Crustacea. I have further shown that the young of Macroura represents even Entomostraca forms, some of these young having been described as representatives of that order.[6] The correspondence between the gradation of Insects and their embryonic growth, I have illustrated fully in a special paper.[7] Similar comparisons have been made in the class of Fishes;[8] among Reptiles, we find the most striking examples

[1] See the works quoted from p. 67–87, also MILNE-EDWARDS, q. a., p. 112.—THOMPSON, Crinoids, q. a.

[2] MÜLLER, (J.) Ueber Pentacrinus Caput-Medusæ, Berlin, 1833, 4to., Ak. d. Wiss.

[3] FORBES, (ED.) History of British Starfishes, London, 1851, 1 vol. 8vo., p. 10.

[4] DANA, q. a., p. 32.—BURMEISTER, Cirripeds, q. a., p. 79.—THOMPSON, q. a., p. 79.

[5] RATHKE, q. a., p. 79.

[6] Twelve Lectures, etc., p. 67.

[7] Classification of Insects, q. a.

[8] Poissons fossiles, q. a.

of this kind among Batrachians[1] (see, above, Sect. XII.); among Birds,[2] the uniformly webbed foot, in all young, exhibits another correspondence between the young of higher orders and the permanent character of the lower ones. In the order of Carnivora, the Seals, the Plantigrades, and the Digitigrades exemplify the same coincidence between higher and higher representatives of the same types, and the embryonic changes through which the highest pass successively.

No more complete evidence can be needed to show that there exists throughout the animal kingdom the closest correspondence between the gradation of their types and the embryonic changes their respective representatives exhibit throughout. And yet what genetic relation can there exist between the Pentacrinus of the West Indies and the Comatulæ, found in every sea; what between the embryos of Spatangoids and those of Echinoids, and between the former and the adult Echinus; what between the larva of a Crab and our Lobsters; what between the Caterpillar of a Papilio and an adult Tinea, or an adult Sphinx; what between the Tadpole of a Toad and our Menobranchus; what between a young Dog and our Seals, unless it be the plan designed by an intelligent Creator?

SECTION XXVIII.

RELATIONS BETWEEN THE STRUCTURE, EMBRYONIC GROWTH, GEOLOGICAL SUCCESSION, AND THE GEOGRAPHICAL DISTRIBUTION OF ANIMALS.

It requires unusual comprehensiveness of view to perceive the order prevailing in the geographical distribution of animals. We should, therefore, not wonder that this branch of Zoölogy is so far behind the other divisions of that science. Nor should we wonder at the fact that the geographical distribution of plants is so much better known than that of animals, when we consider how marked a feature the vegetable carpet which covers the surface of our globe is, when compared with the little show animals make, almost everywhere. And yet it will, perhaps, some day, be easier to understand the relations existing between the geographical distribution of animals and the other general relations prevailing among animals, because the range of structural differences is much greater among animals than among plants. Even now, some curious coincidences may be pointed out which go far to show that the geographical distribution of animals stands in direct relation to their rela-

[1] Twelve Lectures, etc., p. 8.

[2] AGASSIZ, (L.,) Lake Superior, etc., p. 194.

tive standing in their respective classes, and to the order of their succession in past geological ages, and more indirectly, also, to their embryonic growth.

Almost every class has its tropical families, and these stand generally highest in their respective classes; or, when the contrary is the case, when they stand evidently upon a lower level, there is some prominent relation between them and the prevailing types of past ages. The class of Mammalia affords striking examples of these two kinds of connection. In the first place, the Quadrumana, which, next to Man, stand highest in their class, are all tropical animals; and it is worthy of remark, that the two highest types of Anthropoid Monkeys, the Orangs of Asia and the Chimpanzees of Western Africa bear, in the coloration of their skin, an additional similarity to the races of Man inhabiting the same regions, the Orangs being yellowish red, as the Malays, and the Chimpanzee blackish, as the Negroes. The Pachyderms, on the contrary, stand low in their class, though chiefly tropical; but they constitute a group of animals prominent among the earliest representatives of that class in past ages. Among Chiroptera, the larger frugivorous representatives are essentially tropical; the more omnivorous, on the contrary, occur everywhere. Among Carnivora, the largest, most powerful, and also highest types, the Digitigrade, prevail in the tropics, while among the Plantigrades, the most powerful, the Bears, belong to the temperate and to the arctic zone, and the lowest, the Pinnate, are marine species of the temperate and arctic seas. Among Ruminants, we find the Giraffe and the Camels in the warmer zones, the others everywhere. In the class of Birds the gradation is not so obvious as in other classes, and yet the aquatic types form by far the largest representation of this class in temperate and cold regions, and are almost the only ones found in the arctic, while the higher land birds prevail in the warm regions. Among Reptiles, the Crocodilians are entirely tropical; the largest land Turtles are also only found in the tropics, and the aquatic representatives of this order, which are evidently inferior to their land kindred, extend much further north. The Rattlesnakes and Vipers extend further north and higher up the mountains than the Boas and the common harmless snakes. The same is true of Salamanders and Tritons. The Sharks and Skates are most diversified in the tropics. It is also within the tropics that the most brilliant diurnal Lepidoptera are found, and this is the highest order of Insects. Among Crustacea the highest order, the Brachyoura, are most numerous in the torrid zone; but Dana has shown, what was not at all expected, that they nevertheless reach their highest perfection in the middle temperate regions.[1] The Anomoura and Macroura, on the contrary, are nearly equally divided between the torrid and temperate zones; while the lower Tetradecapods are far more numerous in extra tropical latitudes than in the tropical. The

[1] DANA, Crustacea, p. 1501.

Cephalopods are most diversified within the tropics; yet the Nautilus is a reminiscence of past ages. Among Gasteropods, the Stromboids belong to the tropics; but among the lamellibranchiate Acephala, the Naiades, which seem to me to stand very high in their class, have their greatest development in the fresh waters of North America. The highest Echinoderms, the Holothurians and Spatangoids are most diversified within the tropics, while Echini, Starfishes, and Ophiuræ extend to the arctics. The presence of Pentacrinus in the West Indies has undoubtedly reference to the prevalence of Crinoids in past ages. The Madrepores, the highest among the Actinoid Polypi, are entirely tropical, while the highest Halcyonoids, the Renilla, Veretillum, and Pennatula, extend to the tropics and the temperate zone.

Another interesting relation between the geographical distribution of animals and their representatives in past ages, is the absence of embryonic types in the warm regions. We find in the torrid zone no true representatives of the oldest geological periods; Pentacrinus is not found before the Lias; among Cephalopods we find the Nautilus, but nothing like Orthoceras; Limulus, but nothing like Trilobites.

This study of the relations between the geographical distribution of animals, and their relative standing, is rendered more difficult, and in many respects obscure, by the circumstance that entire types, characterized by peculiar structures, are so strangely limited in their range; and yet, even this shows how closely the geographical distribution of animals is connected with their structure. Why New Holland should have no Monkeys, no Carnivora, no Ruminants, no Pachyderms, no Edentata, is not to be explained; but that this is the case, every zoölogist knows, and is further aware, that the Marsupials[1] of that continental island represent, as it were, the other orders of Mammalia, under their special structural modifications. New Holland appears thus as a continent with the characters of an older geological age. No one can fail, therefore, to perceive of how great an interest for Classification will be a more extensive knowledge of the geographical distribution of animals in general, and of the structural peculiarities exhibited by localized types.

SECTION XXIX.

MUTUAL DEPENDENCE OF THE ANIMAL AND VEGETABLE KINGDOMS.

Though it had long been known, by the experiments of De Saussure, that the breathing process of animals and plants are very different, and that while the for-

[1] See Sect. 11.

mer inhale atmospheric air, and exhale carbonic acid gas, the latter appropriate carbon and exhale oxygen, it was not until Dumas and Bousingault[1] called particularly the attention of naturalists to the subject, that it was fully understood how direct the dependence is of the animal and vegetable kingdoms one upon the other, in that respect, or rather how the one consumes what the other produces, and *vice versâ*, thus tending to keep the balance which either of them would singly disturb to a certain degree. The common agricultural practice of manuring exhibits from another side the dependence of one kingdom upon the other: the undigested particles of the food of animals return to the ground, to fertilize it for fresh production.[2] Again, the whole animal kingdom is either directly or indirectly dependent upon the vegetable kingdom for its sustenance, as the herbivorous animals afford the needful food for the carnivorous tribes. We are too far from the time when it could be supposed that Worms originated in the decay of fruits and other vegetable substances, to need here repetition of what is known respecting the reproduction of these animals. Nor can it be necessary to show how preposterous the assumption would be that physical agents produced plants first, in order that from these, animals might spring forth. Who could have taught the physical agents to make the whole animal world dependent upon the vegetable kingdom?

On the contrary, such general facts as those above alluded to, show, more directly than any amount of special disconnected facts could do, the establishment of a well-regulated order of things, considered in advance; for they exhibit well-balanced conditions of existence, prepared long beforehand, such as only an intelligent being could ordain.

SECTION XXX.

PARASITIC ANIMALS AND PLANTS.

However independent of each other some animals may appear, there are yet many which live only in the closest connection with their fellow-creatures, and which are known only as parasites upon or within them. Such are the intestinal Worms, and all the vermin of the skin.[3] Among plants, the Mistletoe, Orobanche,

[1] DUMAS, Leçon sur la statique chimique des êtres organisés, Ann. Sc. Nat. 2de sér. vol. 6, p. 33; vol. 17, p. 122.

[2] LIEBIG, Agricultural Chemistry; Animal Chemistry.

[3] See above, p. 76, notes 1 and 2, and p. 77, notes 1 and 2; see also RUDOLPHI, (K. A.,) Entozoorum sive Vermium, etc., q. a., p. 31.—BREMSER, (J. G.,) Ueber lebende Würmer im lebenden Menschen, Wien, 1819, 4to.—DUJARDIN, (F.,) Hist. Nat. des Helminthes, etc., q. a., p. 32.—DIESING, (C. M.,) Historia Vermium, etc., q. a., p. 32.

Rafflesia, and many Orchideæ may be quoted as equally remarkable examples of parasitism.

There exists the greatest variety of parasites among animals. It would take volumes to describe them and to write their history, for their relations to the animals and plants upon which they are dependent for their existence are quite as diversified as their form and their structure.

It is important, however, to remark, at the outset, that these parasites do not constitute for themselves one great division of the animal kingdom. They belong, on the contrary, to all its branches; almost every class has its parasites, and in none do they represent one natural order. This fact is very significant, as it shows at once that parasitism is not based upon peculiar combinations of the leading structural features of the animal kingdom, but upon correlations of a more specific character. Nor is the degree of dependence of parasites upon other organized beings equally close. There are those which only dwell upon other animals, while others are so closely connected with them that they cannot subsist for any length of time out of the most intimate relation to the species in which they grow and multiply. Nor do these parasites live upon one class of animals; on the contrary, they are found in all of them.

Among Vertebrata there are few parasites, properly speaking. None among Mammalia. Among Birds, a few species depend upon others to sit upon their eggs and hatch them, as the European Cuckoo, and the North American Cowbird. Among Fishes, some small Ophidiums (Fierasfers) penetrate into the cavity of the body of large Holothuriæ in which they dwell.[1] Echeneis attach themselves to other fishes, but only temporarily. Among Articulata, the number of parasites is largest. It seems to lie in the very character of this type, so remarkable for the outward display of their whole organization, to include the greatest variety of parasites. And it is really among them, that we observe the most extraordinary combinations of this singular mode of existence.

Insects, in general, are more particularly dependent upon plants for their sustenance than herbivorous animals usually are, inasmuch as most of them are limited to particular plants for their whole life, such as the Plant-lice, the Coccus, the Gall Insects. In others, the larvæ only are so limited to particular plants, while the larvæ of others still, such as the Bots, grow and undergo their development under the skin or in the intestines, or in the nasal cavities of other animals. The Ichneumons lay their eggs in the larvæ of other insects, upon which the young larvæ prey until hatched. Among perfect Insects, there are those which live only in community with others, such as the Ant-Hill Insects, the Clavigers, the Clerus,

[1] See above, p. 74, note.

and Bees. Different kinds of Ants live together, if not as parasites one upon another, at least in a kind of servitude. Other Insects live upon the bodies of warm blooded animals, such as the Fleas and Lice, and of these the number is legion. Some Hydrachnas are parasitic upon aquatic Mollusks.[1]

Among Crustacea, there are Crabs constantly living in the shell of Mollusks, such as the Pinnotheres of the Oyster and Mussel. I have found other species upon Sea-Urchins, (Pinnotheres Melittæ, a new species, upon Melitta quinquefora). The Paguri take the shells of Mollusks to protect themselves; while a vast number of Amphipods live upon Fishes, attached to their gills, upon their tongue, or upon their skin, or upon Starfishes.[2] The Cyamus Ceti lives upon the Whale. Some Cirripeds are parasites upon the Whales, others upon Corals. In the family of Lernæans, the females are mostly parasites upon the gills or fins or upon the body of Fishes, while the males are free.

Among Worms this mode of existence is still more frequent, and while some dwell only among Corals, entire families of others consist only of genuine parasites; but here again we find the most diversified relations; for, while some are constantly parasitic, others depend only for a certain period of their life upon other animals for their existence. The young Gordius is a free animal; it then creeps into the body of Insects, and leaves them again to propagate; the young Distoma lives free in the water as Cercaria, and spends the remainder of its life in other animals; the Tænia, on the contrary, is a parasite through life, and only its eggs pass from one animal into the other. But what is most extraordinary in this, as in many other intestinal Worms, is the fact, that while they undergo their first transformations in some kind of animals, they do not reach their complete development until they pass into the body of another higher type, being swallowed up by this while in the body of their first host. Such is the case with many Filariæ, the Tæniæ and Bothrocephali. These at first inhabit lower Fishes, and these Fishes being swallowed by Sharks or Water Birds, or Mice with their Worms being eaten up by Cats, the parasites living in them undergo their final transformation in the latter. Many Worms undertake extensive migrations through the bodies of other animals, before they reach the proper place for their final development.[3]

[1] NITZSCH, (CHR. L.,) Darstellung der Familien und Gattungen der Thierinsekten, Halle, 1818, 8vo. — HAYDEN, (C. v.,) Versuch einer systematischen Eintheilung der Acariden, Isis, 1826, p. 608. — RATZENBURG, (J. S. C.) Die Ichneumonen der Forstinsekten, Berlin, 1844–52, 3 vols. 4to. fig. — CLARK, (BR.,) Observations on the Genus Oestrus, Trans. Lin. Soc., III., p. 289, fig. — KOCH, (C. L.,) Die Pflanzen-Läuse, Aphiden, Nürnberg, 1846, 8vo. fig. — DUGÈS, (ANT.,) Recherches sur l'ordre des Acariens, Ann. Sc. Nat., 2de sér., 1834, I., p. 5, II., p. 18, fig.

[2] I have found a new genus of this family upon Asterias Helianthoides.

[3] See above, p. 76, note 1; SIEBOLD, Wanderung, etc., p. 77, note 1; STEENSTRUP, etc.

Among Mollusks, parasites are very few, if any can properly be called true parasites, as the males of some Cephalopods living upon their own females;[1] as the Gasteropods growing buried in Corals,[2] and the Lithodomus and a variety of Arcas found in Corals. Among Radiata there are no parasites, properly speaking; some of them only attaching themselves by preference to certain plants, while the young of others remain connected with their parent, as in all Corals, and even among Crinoids, as in the Comatula of Charleston.

In all these different cases, the chances that physical agents may have a share in producing such animals are still less than in the cases of independent animals, for here we have superadded to the very existence of these beings all the complicated circumstances of their peculiar mode of existence and their various connections with other animals. Now, if it can already be shown from the mere connections of independent animals, that external circumstances cannot be the cause of their existence, how much less could such an origin be ascribed to parasites! It is true, they have been supposed to originate in the body of the animals upon which they live. What then of those who enter the body of other animals at a somewhat advanced stage of growth, as the Gordius? Is it a freak of his? Or, what of those which only live upon other animals, such as lice; are they the product of the skin? Or, what of those which have to pass from the body of a lower into that of a higher animal, to undergo their final metamorphosis and in which this succession is normal? Was such an arrangement devised by the first animal, or imposed upon the first by the second, or devised by physical agents for the two? Or, what of those in which the females only are parasites? Had the two sexes a different origin? Did perhaps the males and females originate in different ways?

I am at a loss to conceive how the origin of parasites can be ascribed to physical causes, unless, indeed, animals themselves be considered as physical causes, with reference to the parasites they nourish; and if so, why can they not get rid of them, as well as produce them, for it cannot be supposed, that all this is not done consciously, when parasites bear such close structural relations to the various types to which they belong?

The existence of parasitic animals belonging to so many different types of the animal as well as the vegetable kingdom, is a fact of deep meaning, which Man himself cannot too earnestly consider, and, while he may marvel at the fact, take it as a warning for himself, with reference to his boasted and yet legitimate inde-

[1] See above, p. 74, note 1, KÖLLIKER, MÜLLER, VERANY and VOGT, etc.

[2] RÜPPELL, (ED.) Mémoire sur le Magilus antiquus, Trans. Soc. Strasb., 1832, I., fig.

pendence. All relations in nature are regulated by a superior wisdom. May we only learn in the end to conform, within the limits of our own sphere, to the laws assigned to each race!

SECTION XXXI.

COMBINATION IN TIME AND SPACE OF VARIOUS KINDS OF RELATIONS AMONG ANIMALS.

It must occur to every reflecting mind, that the mutual relation and respective parallelism of so many structural, embryonic, geological, and geographical characteristics of the animal kingdom are the most conclusive proof, that they were ordained by a reflective mind, while they present at the same time the side of nature most accessible to our intelligence, when seeking to penetrate the relations between finite beings and the cause of their existence.

The phenomena of the inorganic world are all simple, when compared to those of the organic world. There is not one of the great physical agents, electricity, magnetism, heat, light, or chemical affinity, which exhibits, in its sphere, as complicated phenomena as the simplest organized beings; and we need not look for the highest among the latter, to find them presenting the same physical phenomena as are manifested in the material world, besides those which are exclusively peculiar to them. When, then, organized beings include every thing the material world contains, and a great deal more that is peculiarly their own, how could they be produced by physical causes, and how can the physicists, acquainted with the laws of the material world, and who acknowledge that these laws must have been established at the beginning, overlook that *à fortiori* the more complicated laws which regulate the organic world, of the existence of which there is no trace for a long period upon the surface of the earth, must have been established, later and successively, at the time of the creation of the successive types of animals and plants?

Thus far, we have been considering chiefly the contrasts existing between the organic and inorganic worlds.[1] At this stage of our investigation it may not be out of place to take a glance at some of the coincidences which may be traced between them, especially as they afford direct evidence that the physical world has been ordained in conformity with laws which obtain also among living beings, and disclose, in both spheres equally plainly, the workings of a reflective mind.

[1] Compare Sects. 24, 25, 26, 27, 28, 29, and 30.

It is well known, that the arrangement of the leaves in plants[1] may be expressed by very simple series of fractions, all of which are gradual approximations to, or the natural means between $\frac{1}{2}$ or $\frac{1}{3}$, which two fractions are themselves the maximum and the minimum divergence between two single successive leaves. The normal series of fractions which expresses the various combinations most frequently observed among the leaves of plants, is as follows: $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{5}{13}$, $\frac{8}{21}$, $\frac{13}{34}$, $\frac{21}{55}$, etc. Now, upon comparing this arrangement of the leaves in plants with the revolutions of the members of our solar system, Peirce has discovered the most perfect identity between the fundamental laws which regulate both, as may be at once seen by the following diagram, in which the first column gives the names of the planets, the second column indicates the actual time of revolution of the successive planets, expressed in days, the third column the successive times of revolution of the planets, which are derived from the hypothesis that each time of revolution should have a ratio to those upon each side of it, which shall be one of the ratios of the law of phyllotaxis; and the fourth column, finally, gives the normal series of fractions expressing the law of the phyllotaxis.

Neptune,	60,129	62,000		
Uranus,	30,687	31,000		$\frac{1}{2}$
Saturn,	10,759	10,333		$\frac{1}{3}$
Jupiter,	4,333	4,133		$\frac{2}{5}$
Asteroids,	1,200 to 2,000	1,550		$\frac{3}{8}$
Mars,	687	596		$\frac{5}{13}$
Earth,	365	366	$\frac{8}{13}$	$\frac{8}{21}$ (for Earth and Venus)
Venus,	225	227	$\frac{13}{21}$	
Mercury,	88	87		$\frac{13}{34}$

In this series the Earth forms a break; but this apparent irregularity admits of an easy explanation. The fractions $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{5}{13}$, $\frac{8}{21}$, $\frac{13}{34}$, etc., as expressing the position of successive leaves upon an axis, by the short way of ascent along the spiral, are identical, as far as their meaning is concerned, with the fractions expressing these same positions, by the long way, namely, $\frac{1}{2}$, $\frac{2}{3}$, $\frac{3}{5}$, $\frac{5}{8}$, $\frac{8}{13}$, $\frac{13}{21}$, $\frac{21}{34}$, etc.

Let us, therefore, repeat our diagram in another form, the third column giving the theoretical time of revolution.

Neptune,	1	62,000	60,129
"	1	62,000	——
Uranus,	$\frac{1}{2}$	31,000	30,687
"	$\frac{1}{2}$	15.500	——

[1] See the works quoted above, p. 18, note 3.

Saturn,	$\frac{2}{5}$	10,833	10,759
"	$\frac{2}{5}$	6,889	——
Jupiter,	$\frac{3}{8}$	4,133	4,333
"	$\frac{3}{8}$	2,480	——
Asteroids,	$\frac{5}{8}$	1,550	1,200
"	$\frac{5}{8}$	968	——
Mars,	$\frac{5}{13}$	596	687
Earth,	$\frac{8}{13}$	366	365
Venus,	$\frac{13}{21}$	227	225
"	$\frac{13}{21}$	140	——
Mercury,	$\frac{21}{34}$	87	88

It appears from this table, that two intervals usually elapse between two successive planets, so that the normal order of actual fractions is $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{5}{13}$, etc., or the fractions by the short way in phyllotaxis, from which, however, the Earth is excluded, while it forms a member of the series by the long way. The explanation of this, suggested by Peirce, is that although the tendency to set off a planet is not sufficient at the end of a single interval, it becomes so strong near the end of the second interval, that the planet is found exterior to the limit of this second interval. Thus, Uranus is rather too far from the Sun relatively to Neptune, Saturn relatively to Uranus, and Jupiter relatively to Saturn, and the planets thus formed engross too large a proportionate share of material, and this is especially the case with Jupiter. Hence, when we come to the Asteroids, the disposition is so strong at the end of a single interval, that the outer Asteroid is but just within this interval, and the whole material of the Asteroids is dispersed in separate masses over a wide space, instead of being concentrated into a single planet. A consequence of this dispersion of the forming agents is, that a small proportionate material is absorbed into the Asteroids. Hence, Mars is ready for formation so far exterior to its true place, that when the next interval elapses the residual force becomes strong enough to form the Earth, after which the normal law is resumed without any further disturbance. Under this law, there can be no planet exterior to Neptune, but there may be one interior to Mercury.

Let us now look back upon some of the leading features alluded to before, omitting the simpler relations of organized beings to the world around, or those of individuals to individuals, to consider only the different parallel series we have been comparing when showing that, in their respective great types, the phenomena of animal life correspond to one another, whether we compare their rank as determined by structural complication with the phases of their growth, or with their succession in past geological ages; whether we compare this succession with their embryonic growth, or all these different relations with each other and with the geographical distribution of animals upon earth. The same series everywhere![1] These facts are true of all the great divisions of the animal kingdom, so far as we have pursued the investigation; and though, for want of materials, the train of evidence is incomplete in some instances, yet we have proof enough for the establishment of this law of a universal correspondence in all the leading features which binds all organized beings, of all times, into one great system, intellectually and intelligibly linked together, even where some links of the chain are missing. It requires considerable familiarity with the subject even to keep in mind the evidence, for, though yet imperfectly understood, it is the most brilliant result of the combined intellectual efforts of hundreds of investigators during half a century. The connection, however, between the facts, it is easily seen, is only intellectual; and implies, therefore, the agency of Intellect as its first cause.[2]

And if the power of thinking connectedly is the privilege of cultivated minds only; if the power of combining different thoughts, and of drawing from them new thoughts, is a still rarer privilege of a few superior minds; if the ability to trace simultaneously several trains of thought is such an extraordinary gift, that the few cases in which evidence of this kind has been presented have become a matter of historical record (Cæsar dictating several letters at the same time), though they exhibit only the capacity of passing rapidly, in quick succession, from one topic to another, while keeping the connecting thread of several parallel thoughts: if all this is only possible for the highest intellectual powers, shall we by any false argumentation allow ourselves to deny the intervention of a Supreme Intellect in calling into existence combinations in nature, by the side of which, all human conceptions are child's play?

If I have succeeded, even very imperfectly, in showing that the various relations observed between animals and the physical world, as well as between themselves, exhibit thought, it follows, that the whole has an Intelligent Author, and it may not be out of place to attempt to point out, as far as possible, the difference there may be between Divine thinking and human thought.

Taking nature as exhibiting thought for my guide, it appears to me, that while human thought is consecutive, Divine thought is simultaneous, embracing at the same time and for ever, in the past, the present, and the future, the most diversified relations among hundreds of thousands of organized beings, each of which may present complications again, which, to study and understand even imperfectly, as for instance, Man himself, Mankind has already spent thousands of years. And yet, all this has been done by one Mind, must be the work of one Mind only, of

[1] Compare all the preceding sections, where every topic is considered separately.

[2] Agassiz, (L.) Contemplations of God in the Kosmos, Christian Examiner, January, 1851, Boston.

Him before whom Man can only bow in grateful acknowledgment of the prerogatives he is allowed to enjoy in this world, not to speak of the promises of a future life.

I have intentionally dismissed many points in my argument with mere questions, in order not to extend unduly a discussion which is after all only accessory to the plan of my work. I have felt justified in doing so because, from the point of view under which my subject is treated, those questions find a natural solution which must present itself to every reader. We know what the intellect of Man may originate, we know its creative power, its power of combination, of foresight, of analysis, of concentration; we are, therefore, prepared to recognize a similar action emanating from a Supreme Intelligence to a boundless extent. We need, therefore, not even attempt to show that such an Intellect may have originated all the Universe contains; it is enough to demonstrate, that the constitution of the physical world, and more particularly the organization of living beings in their connection with the physical world prove, in general, the existence of a Supreme Being, as the Author of all things. The task of science is rather to investigate what has been done, to inquire, if possible, how it has been done, than to ask what is possible for the Deity, as we can know that only by what actually exists. To attack such a position, those who would deny the intervention in nature of a creative mind, must show, that the cause to which they refer the origin of finite beings is by its nature a possible cause, which cannot be denied of a being endowed with the attributes we recognize in God. Our task is therefore completed, as soon as we have proved his existence. It would, nevertheless, be highly desirable that every naturalist, who has arrived at similar conclusions, should go over the subject anew, from his point of view and with particular reference to the special field of his investigations; for so only can the whole evidence be brought out.

I foresee already that some of the most striking illustrations may be drawn from the morphology of the vegetable kingdom, especially from the characteristic succession and systematical combination of different kinds of leaves in the formation of the foliage and the flowers of so many plants, all of which end their development by the production of an endless variety of fruits. The inorganic world, considered in the same light, would not fail to exhibit also unexpected evidence of thought, in the character of the laws regulating the chemical combinations, the action of physical forces, the universal attraction, etc., etc. Even the history of human culture ought to be investigated from this point of view. But I must leave it to abler hands to discuss such topics.

SECTION XXXII.

RECAPITULATION.

In recapitulating the preceding statements, we may present the following conclusions:—

1st.[1] The connection of all these known features of nature into one system exhibits thought, the most comprehensive thought, in limits transcending the highest wonted powers of man.

2d. The simultaneous existence of the most diversified types under identical circumstances exhibits thought, the ability to adapt a great variety of structures to the most uniform conditions.

3d. The repetition of similar types, under the most diversified circumstances, shows an immaterial connection between them; it exhibits thought, proving directly how completely the Creative Mind is independent of the influence of a material world.

4th. The unity of plan in otherwise highly diversified types of animals, exhibits thought; it exhibits more immediately premeditation, for no plan could embrace such a diversity of beings, called into existence at such long intervals of time, unless it had been framed in the beginning with immediate reference to the end.

5th. The correspondence, now generally known as special homologies, in the details of structure in animals otherwise entirely disconnected, down to the most minute peculiarities, exhibits thought, and more immediately the power of expressing a general proposition in an indefinite number of ways, equally complete in themselves, though differing in all their details.

6th. The various degrees and different kinds of relationship among animals which can have no genealogical connection, exhibit thought, the power of combining different categories into a permanent, harmonious whole, even though the material basis of this harmony be ever changing.

7th. The simultaneous existence, in the earliest geological periods in which animals existed at all, of representatives of all the great types of the animal kingdom, exhibits most especially thought, considerate thought, combining power, premeditation, prescience, omniscience.

8th. The gradation based upon complications of structure which may be traced

[1] The numbers inscribed here correspond to the preceding sections, in the same order, so that the reader may at once refer back to the evidence, when needed.

among animals built upon the same plan, exhibits thought, and especially the power of distributing harmoniously unequal gifts.

9th. The distribution of some types over the most extensive range of the surface of the globe, while others are limited to particular geographical areas, and the various combinations of these types into zoölogical provinces of unequal extent, exhibit thought, a close control in the distribution of the earth's surface among its inhabitants.

10th. The identity of structure of these types, notwithstanding their wide geographical distribution, exhibits thought, that deep thought which, the more it is scrutinized, seems the less capable of being exhausted, though its meaning at the surface appears at once plain and intelligible to every one.

11th. The community of structure in certain respects of animals otherwise entirely different, but living within the same geographical area, exhibits thought, and more particularly the power of adapting most diversified types with peculiar structures to either identical or to different conditions of existence.

12th. The connection, by series, of special structures observed in animals widely scattered over the surface of the globe, exhibits thought, unlimited comprehension, and more directly omnipresence of mind, and also prescience, as far as such series extend through a succession of geological ages.

13th. The relation there is between the size of animals and their structure and form, exhibits thought; it shows that in nature the quantitative differences are as fixedly determined as the qualitative ones.

14th. The independence, in the size of animals, of the mediums in which they live, exhibits thought, in establishing such close connection between elements so influential in themselves and organized beings so little affected by the nature of these elements.

15th. The permanence of specific peculiarities under every variety of external influences, during each geological period, and under the present state of things upon earth, exhibits thought: it shows, also, that limitation in time is an essential element of all finite beings, while eternity is an attribute of the Deity only.

16th. The definite relations in which animals stand to the surrounding world, exhibit thought; for all animals living together stand respectively, on account of their very differences, in different relations to identical conditions of existence, in a manner which implies a considerate adaptation of their varied organization to these uniform conditions.

17th. The relations in which individuals of the same species stand to one another, exhibit thought, and go far to prove the existence in all living beings of an immaterial, imperishable principle, similar to that which is generally conceded to man only.

18th. The limitation of the range of changes which animals undergo during their growth, exhibits thought; it shows most strikingly the independence of these changes of external influences, and the necessity that they should be determined by a power superior to these influences.

19th. The unequal limitation in the average duration of the life of individuals in different species of animals, exhibits thought; for, however uniform or however diversified the conditions of existence may be under which animals live together, the average duration of life, in different species, is unequally limited. It points, therefore, at a knowledge of time and space, and of the value of time, since the phases of life of different animals are apportioned according to the part they have to perform upon the stage of the world.

20th. The return to a definite norm of animals which multiply in various ways, exhibits thought. It shows how wide a cycle of modulations may be included in the same conception, without yet departing from a norm expressed more directly in other combinations.

21st. The order of succession of the different types of animals and plants characteristic of the different geological epochs, exhibits thought. It shows, that while the material world is identical in itself in all ages, ever different types of organized beings are called into existence in successive periods.

22d. The localization of some types of animals upon the same points of the surface of the globe, during several successive geological periods, exhibits thought, consecutive thought; the operations of a mind acting in conformity with a plan laid out beforehand and sustained for a long period.

23d. The limitation of closely allied species to different geological periods, exhibits thought; it exhibits the power of sustaining nice distinctions, notwithstanding the interposition of great disturbances by physical revolutions.

24th. The parallelism between the order of succession of animals and plants in geological times, and the gradation among their living representatives, exhibit thought; consecutive thought, superintending the whole development of nature from beginning to end, and disclosing throughout a gradual progress, ending with the introduction of man at the head of the animal creation.

25th. The parallelism between the order of succession of animals in geological times and the changes their living representatives undergo during their embryological growth, exhibits thought; the repetition of the same train of thoughts in the phases of growth of living animals and the successive appearance of their representatives in past ages.

26th. The combination, in many extinct types, of characters which, in later ages, appear disconnected in different types, exhibits thought, prophetic thought, foresight; combinations of thought preceding their manifestation in living forms.

27th. The parallelism between the gradation among animals and the changes they undergo during their growth, exhibits thought, as it discloses everywhere the most intimate connection between essential features of animals which have no necessary physical relation, and can, therefore, not be understood otherwise than as established by a thinking being.

28th. The relations existing between these different series and the geographical distribution of animals, exhibit thought; they show the omnipresence of the Creator.

29th. The mutual dependence of the animal and vegetable kingdoms for their maintenance, exhibits thought; it displays the care with which all conditions of existence, necessary to the maintenance of organized beings, have been balanced.

30th. The dependence of some animals upon others or upon plants for their existence, exhibits thought; it shows to what degree the most complicated combinations of structure and adaptation can be rendered independent of the physical conditions which surround them.

We may sum up the results of this discussion, up to this point, in still fewer words:—

All organized beings exhibit in themselves all those categories of structure and of existence upon which a natural system may be founded, in such a manner that, in tracing it, the human mind is only translating into human language the Divine thoughts expressed in nature in living realities.

All these beings do not exist in consequence of the continued agency of physical causes, but have made their successive appearance upon earth by the immediate intervention of the Creator. As proof, I may sum up my argument in the following manner:

The products of what are commonly called physical agents are everywhere the same, (that is, upon the whole surface of the globe,) and have always been the same (that is, during all geological periods); while organized beings are everywhere different and have differed in all ages. Between two such series of phenomena there can be no causal or genetic connection.

31st. The combination in time and space of all these thoughtful conceptions exhibits not only thought, it shows also premeditation, power, wisdom, greatness, prescience, omniscience, providence. In one word, all these facts in their natural connection proclaim aloud the One God, whom man may know, adore, and love; and Natural History must, in good time, become the analysis of the thoughts of the Creator of the Universe, as manifested in the animal and vegetable kingdoms.

It may appear strange that I should have included the preceding disquisition in that part of my work which is headed Classification. Yet, it has been done deliberately. In the beginning of this chapter, I have already stated that Classification seems to me to rest upon too narrow a foundation when it is chiefly based upon structure. Animals are linked together as closely by their mode of development, by their relative standing in their respective classes, by the order in which they have made their appearance upon earth, by their geographical distribution, and generally by their connection with the world in which they live, as by their anatomy. All these relations should, therefore, be fully expressed in a natural classification; and though structure furnishes the most direct indication of some of these relations, always appreciable under every circumstance, other considerations should not be neglected, which may complete our insight into the general plan of creation.

In characterizing the great branches of the animal kingdom, it is not enough to indicate the plan of their structure, in all its peculiarities; there are possibilities of execution which are at once suggested to the exclusion of others, and which should also be considered, and so fully analyzed, that the various modes in which such a plan may be carried out shall at once be made apparent. The range and character of the general homologies of each type should also be illustrated, as well as the general conditions of existence of its representatives. In characterizing classes, it ought to be shown why such groups constitute a class and not merely an order, or a family; and to do this satisfactorily, it is indispensable to trace the special homologies of all the systems of organs which are developed in them. It is not less important to ascertain the foundation of all the subordinate divisions of each class; to know how they differ, what constitutes orders, what families, what genera, and upon what characteristics species are based in every natural division. This we shall examine in the next chapter.

CHAPTER SECOND.

LEADING GROUPS OF THE EXISTING SYSTEMS OF ANIMALS.

SECTION I.

GREAT TYPES OR BRANCHES OF THE ANIMAL KINGDOM.

The use of the terms types, classes, orders, families, genera, and species, in the systems of Zoölogy and Botany, is so universal, that it would be natural to suppose that their meaning and extent are well determined and generally understood; but this is so far from being the case that it may on the contrary be said, that there is no subject in Natural History respecting which there exists more uncertainty or a greater want of precision. Indeed, I have failed to find anywhere a definition of the character of most of the more comprehensive of these divisions, while the current views respecting genera and species are very conflicting. Under these circumstances, it has appeared to me particularly desirable to inquire into the foundation of these distinctions, and to ascertain, if possible, how far they have a real existence. And, while I hope the results of this inquiry may be welcome and satisfactory, I am free to confess that it has cost me years of labor to arrive at a clear conception of their true character.

It is such a universal fact in every sphere of intellectual activity, that practice anticipates theory, that no philosopher should be surprised to find that zoölogists have adopted instinctively natural groups, in the animal and vegetable kingdoms, even before the question of the character and of the very existence of such groups in nature was raised. Did not nations speak, understand, and write Greek, Latin, German, and Sanscrit, before it was even suspected that these languages, and so many others, were kindred? Did not painters produce wonders with colors before the nature of light was understood? Had not men been thinking about themselves and the world before logic and metaphysics were taught in schools?

Why, then, should not observers of nature have appreciated rightly the relationship between animals or plants before getting a scientific clue to the classifications they were led to adopt as practical?

Such considerations, above all others, have guided and encouraged me while I was seeking for the meaning of all these systems, so different one from the other in their details, and yet so similar in some of their general features. The history of our science shows how early some of the principles, which obtain to this day, have been acknowledged by all reflecting naturalists. Aristotle, for instance, already knew the principal differences which distinguish Vertebrata from all other animals, and his distinction of *Enaima* and *Anaima*[1] corresponds exactly to that of *Vertebrata* and *Invertebrata* of Lamarck,[2] or to that of *Flesh-* and *Gut-Animals* of Oken,[3] or to that of *Myeloneura* and *Ganglioneura* of Ehrenberg;[4] and one who is at all familiar with the progress of science at different periods can but smile at the claims to novelty or originality so frequently brought forward for views long before current among men. Here, for instance, is one and the same fact presented in different aspects; first, by Aristotle with reference to the character of the formative fluid, next by Lamarck with reference to the general frame, — for I will do Lamarck the justice to believe, that he did not unite the Invertebrata simply because they have no skeleton, but because of that something, which even Professor Owen fails to express,[5] and which yet exists, the one cavity of the body in Invertebrata containing all organs, whilst Vertebrata have one distinct cavity for the centres of the nervous system, and another for the organs of the vegetative life. This acknowledgment is due to Lamarck as truly as it would be due to Aristotle not to accuse him of having denied the Invertebrata any fluid answering the office of the blood, though he calls them *Anaima;* for he knew nearly as well as we now know, that there moves a nutritive fluid in their body, though that information is generally denied him because he had no correct knowledge of the circulation of the blood.

Again, when Oken speaks of Flesh-Animals he does not mean that Vertebrates consist of nothing but flesh, or that the Invertebrates have no muscular fibres; but he brings prominently before us the presence, in the former, of those masses, forming mainly the bulk of the body, which consist of flesh and bones as well as blood and nerves, and constitute another of the leading features distinguishing Vertebrata and Invertebrata. Ehrenberg presents the same relations between the same beings as expressed by their nervous system. If we now take the expressions

[1] Histor. Anim., Lib. I., Ch. 5 and 6.

[2] Anim. Vert., 2d édit., vol. 1, p. 313.

[3] Naturphilosophie, 3d edit., p. 400.

[4] Das Naturreich des Menschen: a diagram, upon a large sheet, folio.

[5] Comparat. Anat. of Inv., 2d edit., p. 11.

of Aristotle, Lamarck, Oken, and Ehrenberg together, have we not, as characteristic of their systems, the very words by which every one distinguishes the most prominent features of the body of the higher animals, when speaking of blood relations, of blood and bones, or of having flesh and nerve?

Neither of these observers has probably been conscious of the identity of his classification with that of his predecessors; nor, indeed, should we consider either of them as superfluous, inasmuch as it makes prominent, features more or less different from those insisted upon by the others; nor ought any one to suppose that with all of them the field is exhausted, and that there is no more room for new systems upon that very first distinction among animals.[1] As long as men inquire they will have opportunities to know more upon these topics than those who have gone before them, so inexhaustibly rich is nature in the innermost diversity of her treasures of beauty, order, and intelligence.

So, instead of discarding all the systems which have thus far had little or no influence upon the progress of science, either because they are based upon principles not generally acknowledged or considered worthy of confidence, I have carefully studied them with the view of ascertaining whatever there may be true in them, from the stand-point from which their authors have considered the animal kingdom; and I own that I have often derived more information from such a careful consideration than I had at first expected.

It was not indeed by a lucky hit, nor by one of those unexpected apparitions which, like a revelation, suddenly break upon us and render at once clear and comprehensible what had been dark and almost inaccessible before, that I came to understand the meaning of those divisions called types, classes, orders, families, genera, and species, so long admitted in Natural History as the basis of every system, and yet so generally considered as mere artificial devices to facilitate our studies. For years I had been laboring under the impression that they are founded in nature, before I succeeded in finding out upon what principle they were really based. I soon perceived, however, that the greatest obstacle in the way of ascertaining their true significance lay in the discrepancies among different authors in their use and application of these terms. Different naturalists do not call by the same name groups of the same kind and the same extent: some call genera what others call subgenera; others call tribes, or even families, what are called genera by others;

[1] By way of an example, I would mention the mode of reproduction. The formation of the egg in Vertebrata; its origin, in all of them, in a more or less complicated Graafian vesicle, in which it is nursed; the formation and development of the embryo up to a certain period, etc., etc., are so completely different from what is observed in any of the Invertebrata, that the animal kingdom, classified according to these facts, would again be divided into two great groups, corresponding to the *Vertebrata* and *Invertebrata* of Lamarck, or the *Flesh-* and *Gut-Animals* of Oken, or the *Enaima* and *Anaima* of Aristotle, etc.

even the names of tribe and family have been applied by some to what others call sub-genera; some have called families what others have called orders; some consider as orders what others have considered as classes; and there are even genera of some authors which are considered as classes by others. Finally, in the number and limitation of these classes, as well as in the manner in which they are grouped together, under general heads, there is found the same diversity of opinion. It is, nevertheless, possible, that under these manifold names, so differently applied, groups may be designated which may be natural, even if their true relation to one another have thus far escaped our attention.

It is already certain that most, if not all investigators agree in the limitation, of some groups at least, under whatever name they may call them, and however much they would blame one another for calling them so, or otherwise. I can therefore no longer doubt that the controversy would be limited to definite questions, if naturalists could only be led to an agreement respecting the real nature of each kind of groups. I am satisfied, indeed, that the most insuperable obstacle to any exact appreciation of this subject lies in the fact, that all naturalists, without exception, consider these divisions, under whatever name they may designate them, as strictly subordinate one to the other, in such a manner, that their difference is only dependent upon their extent; the class being considered as the more comprehensive division, the order as the next extensive, the family as more limited, the genus as still more limited, and the species as the ultimate limitation in a natural arrangement of living beings, so that all these groups would differ only by the quantity of their characters, and not by the quality, as if the elements of structure in animals were all of the same kind; as if the form, for instance, was an organic element of the same kind as the complication of structure, and as if the degree of complication implied necessarily one plan of structure to the exclusion of another. I trust I shall presently be able to show that it is to a neglect of these considerations that we must ascribe the slow progress which has been made in the philosophy of classification.

Were it possible to show that all these groups do not differ in quantity, and are not merely divisions of a wider or more limited range, but are based upon different categories of characters, genera would be called genera by all, whether they differ much or little one from the other, and so would families be called families, orders be called orders, etc. Could, for instance, species be based upon absolute size, genera upon the structure of some external parts of the body, families upon the form of the body, orders upon the similarity of the internal structure, or the like, it is plain that there could not be two opinions respecting these groups in any class of the animal kingdom. But as the problem is not so simple in nature, it was not until after the most extensive investigations, that I seized the clue to guide me through this labyrinth. I knew, for instance, that though naturalists have been disputing, and are still disputing, about species and genera, they all distinguished the things themselves in pretty much the same manner. What A would call a species, B called only a variety or a race; but then B might call a subgenus the very same aggregate of individuals which A called a species; or what A called a genus was considered by B as a family or an order. Now it was this something called no matter how, for which I tried to find out characters which would lead all to call it by the same name; thus limiting the practical difficulty in the application of the name to a question of accuracy in the observations, and no longer allowing it to be an eternal contest about mere nomenclature.

At this stage of my investigation it struck me, that the character of the writings of eminent naturalists might throw some light upon the subject itself. There are authors, and among them some of the most celebrated contributors to our knowledge in Natural History, who never busied themselves with classification, or paid only a passing notice to this subject, whilst they are, by universal consent, considered as the most successful biographers of species; such are Buffon, Reaumur, Roesel, Trembley, Smeathman, the two Hubers, Bewick, Wilson, Audubon, Naumann, etc. Others have applied themselves almost exclusively to the study of genera. Latreille is the most prominent zoölogist of this stamp; whilst Linnæus and Jussieu stand highest among botanists for their characteristics of genera, or at least for their early successful attempts at tracing the natural limits of genera. Botanists have thus far been more successful than zoölogists in characterizing natural families, though Cuvier and Latreille have done a great deal in that same direction in Zoölogy, whilst Linnæus was the first to introduce orders in the classification of animals. As to the higher groups, such as classes and types, and even the orders, we find again Cuvier leading the procession, in which have followed all the naturalists of this century.

Now let us inquire what these men have done in particular to distinguish themselves especially, either as biographers of species, or as characterizers of genera, of families, of orders, of classes, and of types. And should it appear that in each case they have been considering their subject from some particular point of view, it strikes me that what has been acknowledged unconsciously as constituting the particular eminence or distinction of these men, might very properly be proclaimed, with grateful consciousness of their services, as the characteristic of that kind of groups which each of them has most successfully illustrated; and I hope every unprejudiced naturalist will agree with me in this respect.

As to the highest divisions of the animal kingdom, first introduced by Cuvier under the name of *embranchements*, (and which we may well render by the good old English word *branch*.) he tells us himself that they are founded upon distinct plans of structure, cast, as it were, into distinct moulds or forms.[1] Now there can certainly be no reason why we should not all agree to designate as types or branches all such great divisions of the animal kingdom as are constituted upon a special plan,[2] if we should find practically that such groups may be traced in nature. Those who may not see them may deny their existence; those who recognize them may vary in their estimation of their natural limits; but all can, for the greatest benefit of science, agree to call any group which seems to them to be founded upon a special plan of structure, a type or branch of the animal kingdom; and if there are still differences of opinion among naturalists respecting their limits, let the discussion upon this point be carried on with the understanding that types are to be characterized by different plans of structure, and not by special anatomical peculiarities. Let us avoid confounding the idea of plan with that of complication of structure, even though Cuvier himself has made this mistake here and there in his classification.

The best evidence I can produce that the idea of distinct plans of structure is the true pivot upon which the natural limitation of the branches of the animal kingdom is ultimately to turn, lies in the fact that every great improvement, acknowledged by all as such, which these primary divisions have undergone, has consisted in the removal from among each, of such groups as had been placed with them from other considerations than those of a peculiar plan, or in consequence of a want of information respecting their true plan of structure. Let us examine this point within limits no longer controvertible. Neither Infusoria nor Intestinal Worms are any longer arranged by competent naturalists among Radiata. Why they have been removed, may be considered elsewhere; but it was certainly not because they were supposed to agree in the plan of their structure with the

[1] It would lead me too far were I to consider here the characteristics of the different kingdoms of Nature. I may, however, refer to the work of I. GEOFFROY ST. HILAIRE, Histoire naturelle générale des règnes organiques, Paris, 1856, 8vo., who has discussed this subject recently, though I must object to the admission of a distinct kingdom for Man alone.

[2] It is almost superfluous for me to mention here that the terms plan, ways and means, or manner in which a plan is carried out, complication of structure, form, details of structure, ultimate structure, relations of individuals, frequently used in the following pages, are taken in a somewhat different sense from their usual meaning, as is always necessary when new views are introduced in a science, and the adoption of old expressions, in a somewhat modified sense, is found preferable to framing new ones. I trust the value of the following discussion will be appreciated by its intrinsic merit, tested with a willingness to understand what has been my aim, and not altogether by the relative degree of precision and clearness with which I may have expressed myself, as it is almost impossible, in a first attempt of this kind, to seize at once upon the form best adapted to carry conviction. I wish also to be understood as expressing my views more immediately with reference to the animal kingdom, as I do not feel quite competent to extend the inquiry and the discussion to the vegetable kingdom, though I have occasionally alluded to it, as far as my information would permit.

true Radiata, that Cuvier placed them in that division, but simply because he allowed himself to depart from his own principle, and to add another consideration, besides the plan of structure, as characteristic of Radiata,—the supposed absence of a nervous system, and the great simplicity of structure of these animals;—as if simplicity of execution had any necessary connection with the plan of structure. Another remarkable instance of the generally approved removal of a class from one of the types of Cuvier to another, was the transfer of the Cirripeds from among the Mollusks to the branch of Articulata. Imperfect knowledge of the plan of structure of these animals was here the cause of the mistake, which was corrected without any opposition, as soon as they became better known.

From a comparison of what is stated here respecting the different plans of structure, characteristic of the primary divisions of the animal kingdom, with what I have to say below about classes and orders, it will appear more fully, that it is important to make a distinction between the plan of a structure and the manner in which that plan is carried out, or the degrees of its complication and its relative perfection or simplicity. But even after it is understood that the plan of structure should be the leading characteristic of these primary groups, it does not yet follow, without further examination, that the four great branches of the animal kingdom, first distinguished by Cuvier, are to be considered as the primary divisions which Nature points out as fundamental. It will still be necessary, by a careful and thorough investigation of the subject, to ascertain what these primary groups are; but we shall have gained one point with reference to our systems,—that whatever these primary groups, founded upon different plans, which exist in nature, may be, when they are once defined, or whilst they are admitted as the temporary expression of our present knowledge, they should be called the branches of the animal kingdom, whether they be the Vertebrata, Articulata, Mollusca, and Radiata of Cuvier, or the Artiozoaria, Actinozoaria, and Amorphozoaria of Blainville, or the Vertebrata and Invertebrata of Lamarck. The special inquiry into this point must be left for a special paper. I will only add that I am daily more satisfied, that, in their general outlines, the primary divisions of Cuvier are true to nature, and that never did a naturalist exhibit a clearer and deeper insight into the most general relations of animals than Cuvier, when he perceived, not only that these primary groups are founded upon differences in the plan of their structure, but also how they are essentially related to one another.

Though the term type is generally employed to designate the great fundamental divisions of the animal kingdom, I shall not use it in future, but prefer for it the term branch of the animal kingdom, because the term type is employed in too many different acceptations, and quite as commonly to designate any group of any kind, or any peculiar modification of structure stamped with a distinct and marked character, as to designate the primary divisions of the animal kingdom. We speak, for instance, of specific types, generic types, family types, ordinal types, classic types, and also of a typical structure. The use of the word type in this sense is so frequent on almost every page of our systematic works, in Zoölogy and in treatises of Comparative Anatomy, that it seems to me desirable, in order to avoid every possible equivocation in the designation of the most important great primary divisions among animals, to call them branches of the animal kingdom, rather than types.

That, however, our systems are more true to nature than they are often supposed to be, seems to me to be proved by the gradual approximation of scientific men to each other, in their results, and in the forms by which they express those results. The idea which lies at the foundation of the great primary divisions of the animal kingdom is the most general conception possible in connection with the plan of a definite creation; these divisions are, therefore, the most comprehensive of all, and properly take the lead in a natural classification, as representing the first and broadest relations of the different natural groups of the animal kingdom, the general formula which they each obey. What we call branches expresses, in fact, a purely ideal connection between animals, the intellectual conception which unites them in the creative thought. It seems to me that the more we examine the true significance of this kind of groups, the more we shall be convinced that they are not founded upon material relations. The lesser divisions which succeed next are founded upon special qualifications of the plan, and differ one from the other by the character of these qualifications. Should it be found that the features in the animal kingdom which, next to the plan of structure, extend over the largest divisions, are those which determine their rank or respective standing, it would appear natural to consider the orders as the second most important category in the organization of animals. Experience, however, shows that this is not the case; that the manner in which the plan of structure is executed leads to the distinction of more extensive divisions (the classes) than those which are based upon the complication of structure (the orders). As a classification can be natural only as far as it expresses real relations observed in nature, it follows, therefore, that classes take the second position in a system, immediately under the branches. We shall see below that orders follow next, as they constitute naturally groups that are more comprehensive than families, and that we are not at liberty to invert their respective position, nor to transfer the name of one of these divisions to the other, at our own pleasure, as so many naturalists are constantly doing.

SECTION II.

CLASSES OF ANIMALS.

Before Cuvier had shown that the whole animal kingdom is constructed upon four different plans of structure, classes were the highest groups acknowledged in the systems of Zoölogy, and naturalists very early understood upon what this kind of division should be founded, in order to be natural, even though in practice they did not always perceive the true value of the characters upon which they established their standard of relationship. Linnæus, the first expounder of the system of animals, already distinguishes, by anatomical characters, the classes he has adopted, though very imperfectly; and ever since, systematic writers have aimed at drawing a more and more complete picture of the classes of animals, based upon a more or less extensive investigation of their structure.

Structure, then, is the watchword for the recognition of classes, and an accurate knowledge of their anatomy the surest way to discover their natural limits. And yet, with this standard before them, naturalists have differed, and differ still greatly, in the limits they assign to classes, and in the number of them they adopt. It is really strange, that, applying apparently the same standard to the same objects, the results of their estimation should so greatly vary; and it was this fact which led me to look more closely into the matter, and to inquire whether, after all, the seeming unity of standard was not more a fancied than a real one. Structure may be considered from many points of view: first, with reference to the plan adopted in framing it; secondly, with reference to the work to be done by it, and to the ways and means employed in building it up; thirdly, with reference to the degrees of perfection or complication it exhibits, which may differ greatly, even though the plan be the same, and the ways and means employed in carrying out such a plan should not differ in the least; fourthly, with reference to the form of the whole structure and its parts, which bears no necessary relation, at all events no very close relation, to the degree of perfection of the structure, nor to the manner in which its plan is executed, nor to the plan itself, as a comparison between Bats and Birds, between Whales and Fishes, or between Holothurians and Worms, may easily show; fifthly and lastly, with reference to its last finish, to the execution of the details in the individual parts.

It would not be difficult to show, that the differences which exist among naturalists in their limitation of classes have arisen from an indiscriminate consideration of the structure of animals, in all these different points of view, and an equally indiscriminate application of the results obtained, to characterizing classes. Those who have not made a proper distinction between the plan of a structure and the manner in which that plan is actually executed, have either overlooked the importance of the great fundamental divisions of the animal kingdom, or they have unduly multiplied the number of these primary divisions, basing their distinctions upon purely anatomical considerations, that is to say, not upon differences in the character of the general plan of structure, but upon the material development of that plan. Those, again, who have confounded the complication of the structure with the ways and means by which life is maintained through any given combination of systems of organs, have failed in establishing a proper difference between class and ordinal characters, and have again and again raised orders to the rank of classes. For we shall see presently, that natural orders must be based upon the different degrees of complication of structure, exhibited within the limits of the classes, while the classes themselves are characterized by the manner in which the plan of the type is carried out, that is to say, by the various combinations of the systems of organs constituting the body of the representatives of any of the great types of the animal kingdom; or perhaps, still more distinctly, the classes are characterized by the different ways in which life is maintained, and the different means employed in establishing these ways. An example will suffice to show that this distinction implies a marked difference between class and ordinal characters.

Let us compare the Polyps and Acalephs as two classes, without allowing ourselves to be troubled by the different limits assigned to them by different authors. Both are constructed upon the same plan, and belong, on that account, to the type of Radiata. In establishing this fact, we do not consider the actual structure of these animals, whether they have a nervous system or not, whether they have organs of senses or not, whether their muscles are striated or smooth, whether they have a solid frame or an entirely soft body, whether their alimentary cavity has only one opening or two opposite openings, whether it has glandular annexes or not, whether the digested food is distributed in the body one way or another, whether the undigested materials are rejected through the mouth or not, whether the sexes are distinct or not, whether they reproduce themselves only by eggs, or by budding also, whether they are simple or not: all we need know, in order to refer them to the branch of Radiata, is whether the plan of their structure exhibits a general radiated arrangement or not. But, when we would distinguish Polypi, Acalephs, and Echinoderms as classes, or rather, when we would ascertain what are the classes among Radiata, and how many there are, we must inquire into the manner in which this idea of radiation, which lies at the foundation of their plan of structure, is actually expressed in all the animals exhibiting such a plan, and we find easily, that while in some (the Polypi) the body exhibits a large cavity, divided by radiating partitions into a number of chambers, into which hangs a sac, (the digestive cavity,) open below, so as to pour freely the digested food into the main cavity, whence it is circulated to and fro in all the chambers, by the agency of vibrating cilia; in others, (the Acalephs,) the body is plain and full not to be compared to a hollow sac, traversed only in its thickness by radiating tubes, which arise from a central cavity, (the digestive cavity,) without a free communication with one another for their whole length, etc., etc., while in others still, (the Echinoderms,) there is a tough or rigid envelope to the body, inclosing a large cavity in which are contained a variety of distinct systems of organs, etc.

Without giving here a full description of these classes, I only wish to show, that what truly characterizes them, is not the complication of their structure, (for Hydroid Medusæ are hardly more complicated in their structure than Polyps,) but the manner in which the plan of Radiata is carried out, the ways in which life is maintained in these animals, the means applied to this end; in one word, the combinations of their structural elements. But the moment we would discern what are the orders of these classes, these considerations no longer suffice; their structure has to be viewed in a different light; it is now the complication of these apparatus which may guide us. Actinarians and Halcyonarians among Polypi, as orders, differ, the first by having a larger and usually indefinite number of simple tentacles, an equally large number of internal partitions, etc., while in Halcyonarians the eight tentacles are lobed and complicated, and all the parts are combined in pairs, in definite numbers, etc., differences which establish a distinct standing between them in their class, assigning the latter a higher rank than the former.

It follows, then, from the preceding remarks, that classes are to be distinguished by the manner in which the plan of their type is executed, by the ways and means by which this is done, or, in other words, by the combinations of their structural elements, that is to say, by the combinations of the different systems of organs building up the body of their representatives. We need not consider here the various forms under which the structure is embodied, nor the ultimate details, nor the last finish which this structure may exhibit, as a moment's reflection will convince any one that neither form nor structural details can ever be characteristic of classes.

There is another point to which I would call attention, respecting the characteristics of classes. These great divisions, so important in the study of the animal kingdom, that a knowledge of their essential features is rightly considered as the primary object of all investigations in comparative anatomy, are generally represented as exhibiting each some essential modification of the type to which they belong. This view, again, I consider to be a mistaken appreciation of the facts, to which Cuvier has already called attention, though his warning has remained unnoticed.[1] There is in reality no difference in the plan of animals belonging to different classes of the same branch. The plan of structure of Polypi is no more a modification of that of Acalephæ, than that of Acalephæ or Echinoderms is a modification of the plan of Polyps; the plan is exactly the same in all three; it may be represented by one simple diagram, and may be expressed in one single word, radiation; it is the manifestation of one distinct, characteristic idea. But this idea is exhibited in nature under the most different forms, and expressed in different ways, by the most diversified combinations of structural modifications and in the most varied relations. In the innumerable representatives of each branch of the animal kingdom, it is not the plan that differs, but the manner in which this plan is executed. In the same manner as the variations played by a skilful artist upon the simplest tune are not modifications of the tune itself, but only different expressions of the same fundamental harmony, just so are neither the classes, nor the orders, nor the families, nor the genera, nor the species of any great type, modifications of its plan, but only its different expressions, the different ways in which the fundamental thought embodied in it is manifested in a variety of living beings.

In studying the characteristics of classes we have to deal with structural features, while in investigating their relations to the branches of the animal kingdom to which they belong, we have only to consider the general plan, the framework, as it were, of that structure, not the structure itself. This distinction leads to an important practical result. Since, in the beginning of this century, naturalists have begun, under the lead of the German physiophilosophers, to compare more closely the structure of the different classes of the animal kingdom, points of resemblance have been noticed between them which had entirely escaped the attention of earlier investigators, structural modifications have been identified, which, at first, seemed to exhibit no similarity, so much so, that step by step these comparisons have been extended over the whole animal kingdom, and it has been asserted, that, whatever may be the apparent differences in the organization of animals, they should be considered as constructed of parts essentially identical. This assumed identity of structure has been called homology.[2] But the progress of science is gradually restricting these comparisons within narrower limits, and it appears now, that the structure of animals is homologous only as far as they belong to the same branch, so much so, that the study of homologies is likely to afford one of the most trustworthy means of testing the natural limits of any of the

[1] Cuvier, Règn. An., 2d edit., p. 48.

[2] See Chap. I., Sect. 5.

great types of the animal kingdom. While, however, homologies show the close similarity of apparently different structures and the perfect identity of their plan, within the same branches of the animal kingdom, yet, they daily exhibit more and more striking differences, both in plan and structure, between the branches themselves, leading to the suspicion that systems of organs which are generally considered as identical in different types, will, in the end, prove essentially different, as, for instance, the so-called gills in Fishes, Crustacea, and Mollusks.

It requires no great penetration to see already that the gills of Crustacea are homologous with the tracheæ of Insects and the so-called lungs of certain spiders, in the same manner as the gills of aquatic Mollusks are homologous with the so-called lungs of our air-breathing snails and slugs. Now, until it can be shown that all these different respiratory organs are truly homologous, I hold it to be more natural to consider the system of respiratory organs in Mollusks, in Articulates, and in Vertebrates, as essentially different among themselves, though homologous within the limits of each type; and this remark I would extend to all their systems of organs, to their solid frame, to their nervous system, to their muscular system, to their digestive apparatus, to their circulation, and to their reproductive organs, etc. It would not be difficult to show now that the alimentary canal with its glandular appendages, in Vertebrata, is formed in an entirely different way from that of Articulates or Mollusks, and that it cannot be considered as homologous in all these types. And if this be true, we must expect soon an entire reform of our methods of illustrating comparative anatomy.

Finally, it ought to be remembered, in connection with the study of classes as well as that of other groups, that the amount of difference existing between any two divisions is nowhere the same. Some features in nature seem to be insisted upon with more tenacity than others, to be repeated more frequently and more widely, and to be impressed upon a larger number of representatives. This unequal weight of different groups, so evident everywhere in the animal kingdom, ought to make us more cautious in estimating their natural limits, and prevent us from assigning an undue value to the differences observed between living beings, never overrating apparently great discrepancies, nor underrating seemingly trifling variations. The right path, however, can only be ascertained by extensive investigations, made with special reference to this point.

Everybody must know that the males and females of some species differ much more one from the other than many species do, and yet the amount of difference observed between species is constantly urged, even without a preliminary investigation, as an argument for distinguishing them. These differences, moreover, are not only quantitative, they are to a still greater extent also qualitative. In the same manner do genera differ more or less one from the other, even in the same family; and such inequality, and not an equable apportionment, is the norm throughout nature. In classes, it is not only exhibited in the variety of their forms, but also, to an extraordinary extent, in their numbers, as, for instance, in the class of Insects compared to that of Worms or Crustacea. The primary divisions of the animal kingdom differ in the same manner one from the other. Articulata are by far the most numerous branch of the whole animal kingdom; their number exceeding greatly that of all other animals put together. Such facts are in themselves sufficient to show how artificial classifications must be which admit only the same number and the same kind of divisions for all the types of the animal kingdom.

SECTION III.

ORDERS AMONG ANIMALS.

Great as is the discrepancy between naturalists respecting the number and limits of classes in the animal kingdom, their disagreement in regard to orders and families is yet far greater. These conflicting views, however, do not in the least shake my confidence in the existence of fixed relations between animals, determined by thoughtful considerations. I would as soon cease to believe in the existence of one God, because men worship Him in so many different ways, or because they even worship gods of their own making, as distrust the evidence of my own senses respecting the existence of a preëstablished and duly considered system in nature, the arrangement of which preceded the creation of all things that exist.

From the manner in which orders are generally characterized and introduced into our systems, it would seem as if this kind of groups were interchangeable with families. Most botanists make no difference even between orders and families, and take almost universally the terms as mere synonyms. Zoölogists have more extensively admitted a difference between them, but while some consider the orders as superior, others place families higher; others admit orders without at the same time distinguishing families, and *vice versâ* introduce families into their classification without admitting orders; others still admit tribes as intermediate groups between orders and families. A glance at any general work on Zoölogy or Botany may satisfy the student how utterly arbitrary the systems are in this respect. The *Règne animal* of Cuvier exhibits even the unaccountable feature, that while orders and families are introduced in some classes,[1] only orders are noticed in others,[2] and even some exhibit only a succession of genera under the head of their class, without any further grouping among them into orders or families.[3] Other classifications exhibit the most pedantic uniformity of a regular succession in each class, of sub-classes, orders, sub-orders, families, sub-families, tribes, sub-tribes, genera, sub-genera, divisions, sections, and sub-divisions, sub-sections, etc., but bear upon their face, that they are made to suit preconceived ideas of regularity and symmetry in the system, and that they are by no means studied from nature.

To find out the natural characters of orders from that which really exists in nature, I have considered attentively the different systems of Zoölogy in which orders are admitted and apparently considered with more care than elsewhere, and in particular the *Systema Naturæ* of Linnæus, who first introduced in Zoölogy that kind of groups, and the works of Cuvier, in which orders are frequently characterized with unusual precision, and it has appeared to me that the leading idea prevailing everywhere respecting orders, where these groups are not admitted at random, is that of a definite rank among them, the desire to determine the relative standing of these divisions, to ascertain their relative superiority or inferiority, as the name order, adopted to designate them, already implies. The first order in the first class of the animal kingdom, according to the classification of Linnæus, is called by him *Primates*, expressing, no doubt, his conviction that these beings, among which Man is included, rank uppermost in their class. Blainville uses here and there the expression of "degrees of organization," to designate orders. It is true Lamarck uses the same expression to designate classes. We find, therefore, here as everywhere, the same vagueness in the definition of the different kinds of groups adopted in our systems. But if we would give up any arbitrary use of these terms, and assign to them a definite scientific meaning, it seems to me most natural, and in accordance with the practice of the most successful investigators of the animal kingdom, to call orders such divisions as are characterized by different degrees of complication of their structure, within the limits of the classes. As such I would consider, for instance, the Actinoids and Halcyonoids in the class of Polypi, as circumscribed by Dana; the Hydroids, the Discophoræ, and the Cte-

[1] In the classes Mammalia, Birds, Reptiles, and Fishes, Cuvier distinguishes mostly families as well as orders. In the class of Mammalia, some orders number no families, whilst others are divided into tribes instead of families. In the class of Gasteropods, Annelids, Intestinal Worms, and Polyps, some of the orders only are divided into families, while the larger number are not.

[2] The classes Echinoderms, Acalephs, and Infusoria, are divided into orders, but without families.

[3] Such are his classes of Cephalopods, Pteropods, Brachiopods, and Cirripeds (Cirrhopods.) Of the Cephalopods, he says, however, they constitute but one order (Règn. An. vol. 3, p. 11), and, p. 22, he calls them a family, and yet he distinguishes them as a class, p. 8.

noids among Acalephs; the Crinoids, Asterioids, Echinoids, and Holothuriæ among Echinoderms; the Bryozoa, Brachiopods, Tunicata, Lamellibranchiata among Acephala; the Branchifera and Pulmonata among Gasteropods; the Ophidians, the Saurians, and the Chelonians among Reptiles; the Ichthyoids and the Anoura among Amphibians, etc.

Having shown in the preceding paragraph that classes rank next to branches, it would be proper I should show here that orders are natural groups which stand above families in their respective classes; but for obvious reasons I have deferred this discussion to the following paragraph, which relates to families, as it will be easier for me to show what is the respective relation of these two kinds of groups after their special character has been duly considered.

From the preceding remarks respecting orders it might be inferred that I deny all gradation among all other groups, or that I assume that orders constitute necessarily one simple series in each class. Far from asserting any such thing, I hold on the contrary, that neither is necessarily the case. But to explain fully my views upon this point, I must introduce here some other considerations. It will be obvious, from what has already been said, (and the further illustration of this subject will only go to show to what extent this is true,) that there exists an unquestionable hierarchy between the different kinds of groups admitted in our systems, based upon the different kinds of relationship observed among animals, that branches are the most comprehensive divisions, including each several classes, that orders are subdivisions of the classes, families subdivisions of orders, genera subdivisions of families, and species subdivisions of the genera; but not in the sense that each type should necessarily include the same number of classes, nor even necessarily several classes, as this must depend upon the manner in which the type is carried out. A class, again, might contain no orders,[1] if its representatives presented no different degrees characterized by the greater or less complication of their structure; or it may contain many, or few, as these gradations are more or less numerous and well marked; but as the representatives of any and every class have of necessity a definite form, each class must contain at least one family, or many families, indeed, as many as there are systems of forms under which its representatives may be combined, if form can be shown to be characteristic of families. The same is the case with genera and species; and nothing is more remote from the truth than the idea that a genus is better defined in proportion as it contains a greater number of species, or that it may be necessary to know several species of a genus before its existence can be fully ascertained. A genus may be more satisfactorily characterized, its peculiarity more fully ascer-

[1] See Chap. I. Sect. 1.

tained, its limits better defined, when we know all its representatives; but I am satisfied that any natural genus may be at least pointed out, however numerous its species may be, from the examination of any single one of them. Moreover, the number of genera, both in the animal and vegetable kingdom, which contain but a single species, is so great that it is a matter of necessity in all these cases to ascertain their generic characteristics from that one species. Again, such species require to be characterized with as much precision, and their specific characters to be described with as much minuteness, as if a host of them, but not yet known, existed besides. It is a very objectionable practice among zoölogists and botanists, to remain satisfied in such cases with characterizing the genus, and perhaps to believe, what some writers have actually stated distinctly, that in such cases generic and specific characters are identical.

Such being the natural relations and the subordination of types, classes, orders, families, genera, and species, I believe, nevertheless, that neither types, nor classes, (orders of course not at all,) nor families, nor genera, nor species have the same standing when compared among themselves. But this does not in the least interfere with the prominent features of orders, for the relative standing of types, or classes, or families, or genera, or species does not depend upon the degrees of complication of their structures as that of orders does, but upon other features, as I will now show. The four great types or branches of the animal kingdom, characterized as they are by four different plans of structure, will each stand higher or lower, as the plan itself bears a higher or lower character, and that this may be the case we need only compare Vertebrata and Radiata.[1] The different classes of one type will stand higher or lower, as the ways in which and the means with which, the plan of the type to which they belong is carried out, are of a higher or lower nature. Orders in any or all classes are of course higher or lower according to the degree of perfection of their representatives, or according to the complication or simplicity of their structure. Families may stand higher or lower as the peculiarities of their form are determined by modifications of more or less important systems of organs. Genera may stand higher or lower as the structural peculiarities of the parts constituting the generic characteristics exhibit a higher or lower grade of development. Species, lastly, may stand one above the other, in the same genus, according to the character of their relations to the surrounding world, or that of their representatives to one another. These remarks must make it plain that the respective rank of groups of the same kind among themselves must be determined by the superior or inferior grade of those features upon

[1] I must leave out the details of such comparisons, as a mere mention of the point suffices to suggest them; moreover, any text-book of comparative anatomy may furnish the complete evidence to that effect.

which they are themselves founded; while orders alone are strictly defined by the natural degrees of structural complications exhibited within the limits of the classes.

As to the question, whether orders constitute necessarily one simple series in their respective classes, I would say, that this must depend upon the character of the class itself, or the manner in which the plan of the type is carried out within the limits of the class. If the class is homogeneous, that is, if it is not primarily subdivided into sub-classes, the orders will, of course, form a single series; but if some of its organic systems are developed in a different way from the others, there may be one or several parallel series, each subdivided into gradated orders. This can, of course, only be determined by a much more minute study of the characteristics of classes than has been made thus far, and mere guesses at such an internal arrangement of the classes into series, as those proposed by Kaup or Fitzinger, can only be considered as the first attempts towards an estimation of the relative value of the intermediate divisions which may exist between the classes and their orders.

Oken and the physiophilosophers generally have taken a different view of orders. Their idea is, that orders represent, in their respective classes, the characteristic features of the other types of the animal kingdom. As Oken's Intestinal or Gelatinous animals are characterized by a single system of organs, the intestine, they contain no distinct orders, but each class has three tribes, corresponding to the three classes of this type, which are Infusoria, Polypi, and Acalephs. The tribes of the class of Infusoria, are Infusoria proper, Polypoid Infusoria, and Acalephoid Infusoria; the tribes of the class of Polypi, are Infusorial Polypi, Polypi proper, and Acalephoid Polypi; the tribes of the class Acalephs, are Infusorial Acalephs, Polypoid Acalephs, and Acalephs proper. But the classes of Mollusks which are said to be characterized by two systems of organs, the intestine and the vascular system, contain each two orders, one corresponding to the Intestinal animals, the other to the type of Mollusks, and so Acephala are divided into the order of Gelatinous Acephala and that of Molluscoid Acephala, and the Gasteropods and Cephalopods in the same manner into two orders each. The Articulata are considered as representing three systems of organs, the intestinal, the vascular, and the respiratory systems; hence their classes are divided each into three orders. For instance, the Worms contain an order of Gelatinous Worms, one of Molluscoid Worms, one of Annulate Worms, and the same orders are adopted for Crustacea and Insects. Vertebrata are said to represent five systems, the three lower ones being the intestine, the vessels, and the respiratory organs, the two higher the flesh (that is, bones, muscles, and nerves) and the organs of senses; hence, five orders in each class of this type, as, for example, Gelatinous Fishes, Molluscoid Fishes, Entomoid Fishes, Carnal

Fishes, and Sensual Fishes, and so also in the classes of Reptiles, Birds, and Mammalia.[1]

I have entered into so many details upon these vagaries of the distinguished German philosopher, because these views, however crude, have undoubtedly been suggested by a feature of the animal kingdom, which has thus far been too little studied: I mean the analogies which exist among animals, besides their true affinities, and which cross and blend, under modifications of strictly homological structures, other characters which are only analogical. But it seems to me that the subject of analogies is too little known, the facts bearing upon this kind of relationship being still too obscure, to be taken as the basis of such important groups in the animal kingdom as the orders are, and I would insist upon considering the complication or gradation of structure as the feature which should regulate their limitation, if under order we are to understand natural groups expressing the rank, the relative standing, the superiority or inferiority of animals in their respective classes. Of course, groups thus characterized cannot be considered as mere modifications of the classes, being founded upon a special category of features.

SECTION IV.

FAMILIES.

Nothing is more indefinite than the idea of form, as applied by systematic writers, in characterizing animals. Here, it means a system of the most different figures having a common character, as, for instance, when it is said of Zoophytes that they have a radiated form; there, it indicates any outline which circumscribes the body of animals, when, for instance, animal forms are alluded to in general, instead of designating them simply as animals; here, again, it means the special figure of some individual species. There is in fact no group of the animal kingdom, however extensive or however limited, from the branches down to the species, in which the form is not occasionally alluded to as characteristic. Speaking of Articulates, C. E. v. Baer characterizes them as the type with elongated forms; Mollusks are to him the type with massive forms; Radiates that with peripheric symmetry; Vertebrates that with double symmetry, evidently taking their form in its widest sense as expressing the most general relations of the different dimensions of the

[1] See further developments upon this subject in OKEN's Naturphilosophie, and in his Allgemeine Naturgeschichte, vol. 4, p. 582. Compare also the following chapter.

body to one another. Cuvier speaks of form in general with reference to these four great types as a sort of mould, as it were, in which the different types would seem to have been cast. Again, form is alluded to in characterizing orders; for instance, in the distinction between the Brachyourans and the Macrourans among Crustacea, or between the Saurians, the Ophidians, and the Chelonians. It is mentioned as a distinguishing feature in many families, ex. gr. the Cetacea, the Bats, etc. Some genera are separated from others in the same family on the ground of differences of form; and in almost every description of species, especially when they are considered isolatedly, the form is described at full length. Is there not, in this indiscriminate use of the term of form, a confusion of ideas, a want of precision in the estimation of what ought to be called form and what might be designated by another name? It seems to me to be the case. In the first place, when form is considered as characteristic of Radiata or Articulata, or any other of the great types of the animal kingdom, it is evident that it is not a definite outline and well-determined figure which is meant, but that here the word form is used as synonym for plan. Who, for instance, would describe the tubular body of an Holothuria as characterized by a form similar to that of the Euryale, or that of an Echinus as identical with that of an Asterias? And who does not see that, as far as the form is concerned, Holothuriæ resemble Worms much more than they resemble any other Echinoderm, though, as far as the plan of their structure is concerned, they are genuine Radiates, and have nothing to do with the Articulates?

Again, a superficial glance at any and all the classes of the animal kingdom is sufficient to show that each contains animals of the most diversified forms. What can be more different than Bats and Whales, Herons and Parrots, Frogs and Sirens, Eels and Turbots, Butterflies and Bugs, Lobsters and Barnacles, Nautilus and Cuttlefishes, Slugs and Conchs, Clams and compound Asidians, Pentacrinus and Spatangus, Beroe and Physalia, Actinia and Gorgonia? And yet they belong respectively to the same class, as they are coupled here: Bats and Whales together, etc. It must be obvious, then, that form cannot be a characteristic element of classes, if we would understand any thing definite under that name.

But form has a definite meaning understood everywhere, when applied to well-known animals. We speak, for instance, of the human form; an allusion to the form of a horse or that of a bull conveys at once a distinct idea; everybody would acknowledge the similarity of form of the horse and ass, and knows how to distinguish them by their form from dogs or cats, or from seals and porpoises. In this definite meaning, form corresponds also to what we call figure when speaking of men and women, and it is when taken in this sense, that I would now consider the value of forms as characteristic of different animals. We have seen that form cannot be considered as a character of branches, nor of classes; let us now examine, further, whether it is a character of species. A rapid review of some of the best known types of the animal kingdom, embracing well-defined genera with many species, will at once show that this cannot be the case, for such species do not generally show the least difference in their forms. Neither the many species of Squirrels, nor the true Mice, nor the Weasels, nor the Bears, nor the Eagles, nor the Falcons, nor the Sparrows, nor the Warblers, nor the genuine Woodpeckers, nor the true Lizards, nor the Frogs, nor the Toads, nor the Skates, nor the Sharks proper, nor the Turbots, nor the Soles, nor the Eels, nor the Mackerels, nor the Sculpins, nor the genuine Shrimps, nor the Crawfishes, nor the Hawkmoths, nor the Geometers, nor the Dorbugs, nor the Spring-Beetles, nor the Tapeworms, nor the Cuttlefishes, nor the Slugs, nor the true Asterias, nor the Sea-Anemones, could be distinguished among themselves, one from the other, by their form only. There may be differences in the proportions of some of their parts, but the pattern of every species belonging to well-defined natural genera is so completely identical that it will never afford specific characters. There are genera in our system which, as they now stand, might be alluded to as examples contrary to this statement; but such genera are still based upon very questionable features, and are likely to be found in the end to consist of unnatural associations of heterogeneous species: at all events, all recent improvements in Zoölogy have gone to limit genera gradually more and more in such a manner, that the species belonging to each have shown successively less and less difference in form, until they have assumed, in that respect, the most homogeneous appearance. Are natural genera any more to be distinguished by their form one from the other? Is there any appreciable difference in the general form,—I say purposely general form, because a more or less prominent nose, larger or smaller ears, longer or shorter claws, etc., do not essentially modify the form,—is there any real difference in the general form between the genera of the most natural families? Do, for instance, the genera of Ursina, the Bears, the Badger, the Wolverines, the Raccoons, differ in form? Do the Phocoidæ, the Delphinoidæ, the Falconinæ, the Turdinæ, the Fringillinæ, the Picinæ, the Scolopacinæ, the Chelonioidæ, the Geckonina, the Colubrina, the Sparoidæ, the Elateridæ, the Pyralidoidæ, the Echinoidæ, etc., differ any more among themselves? Certainly not; though to some extent, there are differences in the form of the representatives of one genus when compared to those of another genus; but when rightly considered, these differences appear only as modifications of the same type of forms. Just as there are more or less elongated ellipses, so do we find the figure of the Badgers somewhat more contracted than that of either the Bears, or the Raccoons, or the Wolverines, that of the Wolverines somewhat more elongated than that of the Raccoons; but the form is here as completely typical as it is among the Viverrina, or among the Canina, or among the Bradypodidæ, or among the Delphinoidæ, etc., etc. We must, therefore, exclude form from the characteristics of natural genera, or at least introduce it only as a modification of the typical form of natural families.

Of all the natural groups in the animal kingdom there remain then only families and orders, for the distinction of which form can apply as an essential criterion. But these two kinds of groups are just those upon which zoölogists are least agreed, so that it may not be easy to find a division which all naturalists would agree to take as an example of a natural order. Let us, however, do our best to settle the difficulty and suppose, for a moment, that what has been said above respecting the orders is well founded, that orders are natural groups characterized by the degree of complication of their structure, and expressing the respective rank of these groups in their class, then we shall find less difficulty in pointing out some few groups which could be generally considered as orders. I suppose most naturalists would agree, for instance, that among Reptiles the Chelonians constitute a natural order; that among Fishes, Sharks and Skates constitute an order also; and if any one would urge the necessity of associating also the Cyclostomes with them, it would only the better serve my purposes. Ganoids, even circumscribed within narrower limits than those I had assigned to them, and perhaps reduced to the extreme limits proposed for them by J. Müller, I am equally prepared to take as an example, though I have in reality still some objections to this limitation, which, however, do not interfere with my present object. Decapods, among Crustacea, I suppose everybody would also admit as an order, and I do not care here what other families are claimed besides Decapods to complete the highest order of Crustacea. Among Acephala, I trust Bryozoa, Tunicata, Brachiopods, and Lamellibranchiata would be also very generally considered to be natural orders. Among Echinoderms, I suppose Crinoids, Asterioids, Echinoids, and Holothurioids would be conceded also as such natural orders; among Acalephs the Beroids, and perhaps also Discophoræ and Hydroids; while among the Polypi, the Halcyonoids constitute a very natural order when compared with the Actinoids.

Let us now consider these orders with reference to the characteristic forms they include. The forms of the genuine Testudo, of Trionyx, and of Chelonia are very different, one from the other, and yet few orders are so well circumscribed as that of Chelonians. The whole class of Fishes scarcely exhibits greater differences than those observed in the forms of the common Sharks, the Sawfishes, the common Skates, and the Torpedo, not to speak of the Cyclostomes and Myxinoids, if these families were also considered as members of the order of Placoids. Ganoids cannot be circumscribed within narrower limits than those assigned to them by J. Müller, and yet this order, thus limited, contains forms as heterogeneous as the Sturgeons, the Lepidosteus, the Polypterus, the Amia, and a host of extinct genera and families, not to speak of those families I had associated with them and which Prof. Müller would have removed, which, if included among Ganoids, would add still more heteromorphous elements to this order. Among Decapods, we need only remember the Lobsters and Crabs to be convinced that it is not similarity of form which holds them so closely together as a natural order. How heterogeneous Bryozoa, Brachiopods, and Tunicata are among themselves, as far as their form is concerned, everybody knows who has paid the least attention to these animals.

Unless, then, form be too vague an element to characterize any kind of natural groups in the animal kingdom, it must constitute a prominent feature of families. I have already remarked, that orders and families are the groups upon which zoölogists are least agreed, and to the study and characterizing of which they have paid least attention. Does this not arise simply from the fact, that, on the one hand, the difference between ordinal and class characters has not been understood, and only assumed to be a difference of degree; and, on the other hand, that the importance of the form, as the prominent character of families, has been entirely overlooked? For, though so few natural families of animals are well characterized, or characterized at all, we cannot open a modern treatise upon any class of animals without finding the genera more or less naturally grouped together, under the heading of a generic name with a termination in *idæ* or *inæ* indicating family and sub-family distinctions; and most of these groups, however unequal in absolute value, are really natural groups, though far from designating always natural families, being as often orders or sub-orders, as families or sub-families. Yet they indicate the facility there is, almost without study, to point out the intermediate natural groups between the classes and the genera. This arises, in my opinion, from the fact, that family resemblance in the animal kingdom is most strikingly expressed in the general form, and that form is an element which falls most easily under our perception, even when the observation is made superficially. But, at the same time, form is most difficult to describe accurately, and hence the imperfection of most of our family characteristics, and the constant substitution for such characters of features which are not essential to the family. To prove the correctness of this view, I would only appeal to the experience of every naturalist. When we see new animals, does not the first glance, that is, the first impression made upon us by their form, give us at once a very correct idea of their nearest relationship? We perceive, before examining any structural character, whether a Beetle is a Carabicine, a Longicorn, an Elaterid, a Curculionid, a Chrysomeline; whether a Moth is a Noctuelite, a Geometrid, a Pyralid, etc.; whether a bird is a Dove, a Swallow, a Humming-bird, a Woodpecker, a Snipe, a Heron, etc., etc. But before we can ascertain its genus, we have to study the structure of some characteristic parts; before we can combine families into natural groups, we have to make a thorough investigation of their whole structure, and compare it with that of other families. So form is characteristic of families; and I can add, from a careful investigation of the subject for several years past, during which I have reviewed the whole animal kingdom with reference to this and other topics connected with classification, that form is the essential characteristic of families.[1] I do not mean the mere outline, but form as determined by structure; that is to say, that families cannot be well defined, nor circumscribed within their natural limits, without a thorough investigation of all those features of the internal structure which combine to determine the form.

The characteristic of the North American Chelonians which follows, may serve as an example how this subject is to be treated. I will only add here, that however easy it is at first, from the general impression made upon us by the form of animals, to obtain a glimpse of what may fairly be called families, few investigations require more patient comparisons than those by which we ascertain the natural range of modifications of any typical form, and the structural features upon which it is based. Comparative anatomy has so completely discarded every thing that relates to Morphology; the investigations of anatomists lean so uniformly towards a general appreciation of the connections and homologies of the organic systems which go to build up the body of animals, that for the purpose of understanding the value of forms and their true foundation, they hardly ever afford any information, unless it be here and there a consideration respecting teleological relations.

Taking for granted, that orders are natural groups characterized by the complication of their structure, and that the different orders of a class express the different degrees of that complication; taking now further for granted, that families are natural groups characterized by their form as determined by structural peculiarities, it follows that orders are the superior kind of division, as we have seen that the several natural divisions which are generally considered as orders, contain each several natural groups, characterized by different forms, that is to say, constituting as many distinct families.

After this discussion it is hardly necessary to add, that families cannot by any means be considered as modifications of the orders to which they belong, if orders are to be characterized by the degrees of complication of their structure, and families

[1] These investigations, which have led to most interesting results, have delayed thus far the publication of the systematic part of the Principles of Zoölogy, undertaken in common with my friend, Dr. A. A. Gould, and which I would not allow to appear before I could revise the whole animal kingdom in this new light, in order to introduce as much precision as possible in its classification.

by their forms. I would also further remark, that there is one question relating to the form of animals, which I have not touched here, and which it is still more important to consider in the study of plants, namely, the mode of association of individuals into larger or smaller communities, as we observe them, particularly among Polyps and Acalephs. These aggregations have not, as far as their form is concerned, the same importance as the form of the individual animals of which they are composed, and therefore seldom afford trustworthy family characters. But this point may be more appropriately considered in connection with the special illustration of our Hydroids, to which my next volume is to be devoted.

I have stated above, that botanists have defined the natural families of plants with greater precision than zoölogists those of animals; I have further remarked also, that most of them make no distinction between orders and families. This may be the result of the peculiar character of the vegetable kingdom, which is not built upon such entirely different plans of structure as are animals of different branches. On the contrary, it is possible to trace among plants a certain gradation between their higher and lower types more distinctly than among animals, even though they do not, any more than animals, constitute a simple series. It seems to me, nevertheless, that if Cryptogams, Gymnosperms, Monocotyledons, and Dicotyledons can be considered as branches of the vegetable kingdom, analogous to Radiata, Mollusks, Articulata, and Vertebrata among animals, such divisions as Fungi, Algæ, Lichens, Mosses, Hepaticæ, and Ferns in the widest sense, may be taken as classes. Diatomaceæ, Confervæ, and Fuci may then be considered as orders; Mosses and Hepaticæ as orders; Equisetaceæ, Ferns proper, Hydropterids, and Lycopodiaceæ as orders also; as they exhibit different degrees of complication of structure, while their natural subdivisions, which are more closely allied in form or habitus, may be considered as families; natural families among plants having generally as distinct a port, as families among animals have a distinct form. We need only remember the Palms, the Coniferæ, the Umbelliferæ, the Compositæ, the Leguminosæ, the Labiatæ, etc., as satisfactory examples of this kind.

SECTION V.

GENERA.

Linnæus already knew very well that genera exist in nature, though what he calls genera constitute frequently groups to which we give at present other names, as we consider many of them as families; but it stands proved by his writings that he had fully satisfied himself of the real existence of such groups, for he says distinctly in his *Philosophia Botanica*, sect. 169, "Scias characterem non constituere genus, sed genus characterem. Characterem fluere e genere, non genus e charactere. Characterem non esse, ut genus fiat, sed ut genus noscatur."

It is surprising that notwithstanding such clear statements, which might have kept naturalists awake respecting the natural foundation of genera, such loose ideas have become prevalent upon this subject, that at present the number of investigators who exhibit much confidence in the real existence of their own generic distinctions is very limited. And as to what genera really are, the want of precision of ideas appears still greater. Those who have considered the subject at all seem to have come to the conclusion that genera are nothing but groups including a certain number of species agreeing in some more general features than those which distinguish species; thus recognizing no difference between generic and specific characters as such, as a single species may constitute a genus, whenever its characters do not agree with the characters of other species, and many species may constitute a genus, because their specific characters agree to a certain extent among themselves.[1] Far from admitting such doctrines, I hope to be able to show that, however much or however little species may differ among themselves as species, yet they may constitute a natural genus, provided their respective generic characters are identical.

I have stated before, that in order to ascertain upon what the different groups adopted in our systems are founded, I consulted the works of such writers as are celebrated in the annals of science for having characterized with particular felicity any one kind of these groups, and I have mentioned Latreille as prominent among zoölogists for the precision with which he has defined the genera of Crustacea and Insects, upon which he has written the most extensive work extant.[2] An anecdote which I have often heard repeated by entomologists who knew Latreille well, is very characteristic as to the meaning he connected with the idea of genera. At the time he was preparing the work just mentioned, he lost no opportunity of obtaining specimens, the better to ascertain from nature the generic peculiarities of these animals, and he used to apply to the entomologists for contributions to his collection. It was not show specimens he cared to obtain, any would do, for he used to say he wanted them only "to examine their parts." Have we not here a hint, from a master, to teach us what genera are and how they should be characterized? Is it not the special structure of some part or other, which charac-

[1] SPRING, Ueber die naturhistorischen Begriffe von Gattung, Art und Abart, Leipzig, 1838, 1 vol. 8vo.

[2] LATREILLE, Genera Crustaceorum und Insectorum, Paris et Argent. 1806–1809, 4 vols. 8vo.

terizes genera? Is it not the finish of the organization of the body, as worked out in the ultimate details of structure, which distinguishes one genus from another? Latreille, in expressing the want he felt with reference to the study of genera, has given us the key-note of their harmonious relations to one another. Genera are most closely allied groups of animals, differing neither in form, nor in complication of structure, but simply in the ultimate structural peculiarities of some of their parts; and this is, I believe, the best definition which can be given of genera. They are not characterized by modifications of the features of the families, for we have seen that the prominent trait of family difference is to be found in a typical form; and genera of the same family may not differ at all in form. Nor are genera merely a more comprehensive mould than the species, embracing a wide range of characteristics; for species in a natural genus should not present any structural differences, but only such as express the most special relations of their representatives to the surrounding world and to each other. Genera, in one word, are natural groups of a peculiar kind, and their special distinction rests upon the ultimate details of their structure.

SECTION VI.

SPECIES.

It is generally believed that nothing is easier than to determine species, and that of all the degrees of relationship which animals exhibit, that which constitutes specific identity is the most clearly defined. An unfailing criterion of specific identity is even supposed to exist in the sexual connection which so naturally brings together the individuals of the same species in the function of reproduction. But I hold that this is a complete fallacy, or at least a *petitio principii*, not admissible in a philosophical discussion of what truly constitutes the characteristics of species. I am even satisfied that some of the most perplexing problems involved in the consideration of the natural limits of species would have been solved long ago, had it not been so generally urged that the ability and natural disposition of individuals to connect themselves in fertile sexual intercourse was of itself sufficient evidence of their specific identity. Without alluding to the fact that every new case of hybridity[1] is an ever-returning protest against such an assertion, and

[1] WIEGMAN, Gekrönte Preisschrift über die Bastarderzeugung im Pflanzenreich, Braunschweig, 1828, 8vo. — BRAUN, (A.,) Ueber die Erscheinung der Verjüngung in der Natur, Freiburg, 1849, 4to. — MORTON, (S. G.,) Essay on Hybridity, Amer. Jour., 1847. — Additional Observations on Hybridity in Animals and on some collateral subjects, Charleston Med. Journ., 1850.

without entering here into a discussion respecting the possibility or practicability of setting aside this difficulty by introducing the consideration of the limited fertility of the progeny of individuals of different species, I will only remark, that as long as it is not proved that all the varieties of dogs, and of any others of our domesticated animals, and of our cultivated plants, are respectively derived from one unmixed species, and as long as doubts can be entertained respecting the common origin of all races of men from one common stock, it is not logical to admit that sexual connection resulting even in fertile offspring is a trustworthy evidence of specific identity.

To justify this assertion, I would only ask, where is the unprejudiced naturalist who in our days would dare to maintain: 1st, that it is proved that all the domesticated varieties of sheep, of goats, of bulls, of llamas, of horses, of dogs, of fowls, etc., are respectively derived from one common stock; 2d, that the supposition that these varieties have originated from the complete amalgamation of several primitively distinct species is out of the question; and 3d, that varieties imported from distant countries and not before brought together, such as the Shanghae fowl, for instance, do not completely mingle? Where is the physiologist who can conscientiously affirm that the limits of the fertility between distinct species are ascertained with sufficient accuracy to make it a test of specific identity? And who can say that the distinctive characters of fertile hybrids and of unmixed breeds are sufficiently obvious to enable anybody to point out the primitive features of all our domesticated animals, or of all our cultivated plants? As long as this cannot be done, as long as the common origin of all races of men, and of the different animals and plants mentioned above, is not proved, while their fertility with one another is a fact which has been daily demonstrated for thousands of years, as long as large numbers of animals are hermaphrodites, never requiring a connection with other individuals to multiply their species, as long as there are others which multiply in various ways without sexual intercourse, it is not justifiable to assume that those animals and plants are unmixed species, and that sexual fecundity is the criterion of specific identity. Moreover, this test can hardly ever have any practical value in most cases of the highest scientific interest. It is never resorted to, and, as far as I know, has never been applied with satisfactory results to settle any doubtful case. It has never assisted any anxious and conscientious naturalist in investigating the degree of relationship between closely allied animals or plants living in distant regions or in disconnected geographical areas. It will never contribute to the solution of any of those difficult cases of seeming difference or identity between extinct animals and plants found in different geological formations. In all critical cases, requiring the most minute accuracy and precision, it is discarded as unsafe, and of necessity questionable. Accurate science must do without it, and the sooner it is altogether discarded, the better. But, like many relics of past time, it is dragged in as a sort of theoretical bugbear, and exhibited only now and then to make a false show in discussions upon the question of the unity of origin of mankind.

There is another fallacy connected with the prevailing ideas about species to which I would also allude: the fancy that species do not exist in the same way in nature as genera, families, orders, classes, and types. It is actually maintained by some that species are founded in nature in a manner different from these groups; that their existence is, as it were, more real, whilst that of the other groups is considered as ideal, even when it is admitted that these groups have themselves a natural foundation.

Let us consider this point more closely, as it involves the whole question of individuality. I wish, however, not to be understood as undervaluing the importance of sexual relations as indicative of the close ties which unite, or may unite, the individuals of the same species. I know as well as any one to what extent they manifest themselves in nature, but I mean to insist upon the undeniable fact that these relations are not so exclusive as those naturalists would represent them, who urge them as an unfailing criterion of specific identity. I would remind those who constantly forget it, that there are animals which, though specifically distinct do unite sexually, which do produce offspring, mostly sterile, it is true, in some species, but fertile to a limited extent in others, and in others even fertile to an extent which it has not yet been possible to determine. Sexual connection is the result, or rather one of the most striking expressions of the close relationship established in the beginning between individuals of the same species, and by no means the cause of their identity in successive generations. When first created, animals of the same species paired because they were made one for the other; they did not take one another in order to build up their species, which had full existence before the first individual produced by sexual connection was born.

This view of the subject acquires greater importance in proportion as it becomes more apparent that species did not originate in single pairs, but were created in large numbers, in those numeric proportions which constitute the natural harmonies between organized beings. It alone explains the possibility of the procreation of Hybrids, as founded upon the natural relationship of individuals of closely allied species, which may become fertile with one another, the more readily as they differ less, structurally.

To assume that sexual relations determine the species it should further be shown that absolute promiscuousness of sexes among individuals of the same species is the prevailing characteristic of the animal kingdom, while the fact is, that a large number even of animals, not to speak of Man, select their mate for life and rarely have any intercourse with others. It is a fact known to every farmer, that different breeds of the same species are less inclined to mingle than individuals of the same breed. For my own part, I cannot conceive how moral philosophers, who urge the unity of origin of Man as one of the fundamental principles of their religion, can at the same time justify the necessity which it involves of a sexual intercourse between the nearest blood relations of that assumed first and unique human family, when such a connection is revolting even to the savage. Then again, there are innumerable species in which vast numbers of individuals are never developed sexually, others in which sexual individuals appear only now and then at remote intervals, while many intermediate generations are produced without any sexual connection, and others still which multiply more extensively by budding than by sexual generation. I need not again allude here to the phenomena of alternate generation, now so well known among Acalephs and Worms, nor to the polymorphism of many other types. Not to acknowledge the significance of such facts, would amount to the absurd pretension, that distinctions and definitions, introduced in our science during its infancy, are to be taken as standards for our appreciation of the phenomena in nature, instead of framing and remodelling our standards, according to the laws of nature, as our knowledge extends. It is, for instance, a specific character of the Horse and the Ass to be able to connect sexually with each other, and thus to produce an offspring different from that which they bring forth among themselves. It is characteristic of the Mare, as the representative of its species, to bring forth a Mule with the Jackass, and of the Stallion to procreate Hinnies with the She-ass. It is equally characteristic of them to produce still other kinds of halfbreeds with the Zebra, the Daw, etc. And yet in face of all these facts, which render sexual reproduction, or at least promiscuous intercourse among the representatives of the same species, so questionable a criterion of specific identity, there are still naturalists who would represent it as an unfailing test, only that they may sustain one single position, that all men are derived from one single pair.

These facts, with other facts which go to show more extensively every day the great probability of the independent origin of individuals of the same species in disconnected geographical areas, force us to remove from the philosophic definition of species the idea of a community of origin, and consequently, also, the idea of a necessary genealogical connection. The evidence that all animals have originated in large numbers is growing so strong, that the idea that every species existed in the beginning in single pairs, may be said to be given up almost entirely by naturalists. Now if this is the case, sexual derivation does not constitute a necessary specific character, even though sexual connection be the natural process of their reproduction and multiplication. If we are led to admit as the beginning of each species, the simultaneous origin of a large number of individuals, if the same species may originate at the same time in different localities, these first representatives of each species, at least, were not connected by sexual derivation; and as this applies equally to any first pair, this fancied test criterion of specific identity must at all events be given up, and with it goes also the pretended real existence of the species, in contradistinction from the mode of existence of genera, families, orders, classes, and types; for what really exists are individuals, not species. We may at the utmost consider individuals as representatives of species, but no one individual nor any number of individuals represent its species only, without representing also at the same time, as we have seen above (Sect. I. to V.), its genus, its family, its order, its class, its type.

Before attempting to prove the whole of this proposition, I will first consider the characters of the individual animals. Their existence is scarcely limited as to time and space within definite and appreciable limits. No one nor all of them represent fully, at any particular time, their species; they are always only the temporary representatives of the species, inasmuch as each species exists longer in nature than any of its individuals. All the individuals of any or of all species now existing are only the successors of other individuals which have gone before, and the predecessors of the next generations; they do not constitute the species, they represent it. The species is an ideal entity, as much as the genus, the family, the order, the class, or the type; it continues to exist, while its representatives die, generation after generation. But these representatives do not simply represent what is specific in the individual, they exhibit and reproduce in the same manner, generation after generation, all that is generic in them, all that characterizes the family, the order, the class, the branch, with the same fulness, the same constancy, the same precision. Species then exist in nature in the same manner as any other groups, they are quite as ideal in their mode of existence as genera, families, etc., or quite as real. But individuals truly exist in a different way; no one of them exhibits at one time all the characteristics of the species, even though it be hermaphrodite, neither do any two represent it, even though the species be not polymorphous, for individuals have a growth, a youth, a mature age, an old age, and are bound to some limited home during their lifetime. It is true species are also limited in their existence; but for our purpose, we can consider these limits as boundless, inasmuch as we have no means of fixing their duration, either for the past geological ages, or for the present period, whilst the short cycles of the life of individuals are easily measurable quantities. Now as truly as individuals, while they exist, represent their species for the time being, and do not constitute them, so truly do these same individuals represent at the same time their genus, their family, their order, their class, and their type, the characters of which they bear as indelibly as those of the species.

As representatives of Species, individual animals bear the closest relations to one another; they exhibit definite relations also to the surrounding elements, and their existence is limited within a definite period.

As representatives of Genera, these same individuals have a definite and specific ultimate structure, identical with that of the representatives of other species.

As representatives of Families, these same individuals have a definite figure exhibiting, with similar forms of other genera, or for themselves, if the family contains but one genus, a distinct specific pattern.

As representatives of Orders, these same individuals stand in a definite rank when compared to the representatives of other families.

As representatives of Classes, these same individuals exhibit the plan of structure of their respective type in a special manner, carried out with special means and in special ways.

As representatives of Branches, these same individuals are all organized upon a distinct plan, differing from the plan of other types.

Individuals then are the bearers, for the time being, not only of specific characteristics, but of all the natural features in which animal life is displayed in all its diversity.

Viewing individuals in this light, they resume all their dignity; they are no longer absorbed in the species to be for ever its representatives, without ever being any thing for themselves. On the contrary, it becomes plain, from this point of view, that the individual is the worthy bearer, for the time being, of all the riches of nature's wealth of life. This view further teaches us how we may investigate, not only the species in the individual, but the genus also, the family, the order, the class, the type, as indeed naturalists have at all times proved in practice, whilst denying the possibility of it in theory.

Having thus cleared the field of what does not belong therein, it now remains for me to show what in reality constitutes species, and how they may be distinguished with precision within their natural limits.

If we would not exclude from the characteristics of species any feature which is essential to it, nor force into it any one which is not so, we must first acknowledge that it is one of the characters of species to belong to a given period in the history of our globe, and to hold definite relations to the physical conditions then prevailing, and to animals and plants then existing. These relations are manifold, and are exhibited: 1st, in the geographical range natural to any species, as well as in its capability of being acclimated in countries where it is not primitively found; 2d, in the connection in which they stand to the elements around them, when they inhabit either the water, or the land, deep seas, brooks, rivers and lakes, shoals, flat, sandy, muddy, or rocky coasts, limestone banks, coral reefs, swamps, meadows, fields, dry lands, salt deserts, sandy deserts, moist land, forests, shady groves, sunny hills, low regions, plains, prairies, high table-lands, mountain peaks, or the frozen barrens of the Arctics, etc.; 3d, in their dependence upon this or that kind of food for their sustenance; 4th, in the duration of their life; 5th, in the mode of their association with one another, whether living in flocks, small companies, or isolated; 6th, in the period of their reproduction; 7th, in the changes they undergo during their growth, and the periodicity of these changes in their metamorphosis; 8th, in their association with other beings, which is more or less close, as it may only lead to a constant association in some, whilst in others it amounts to parasitism; 9th, specific characteristics are further exhibited in the size animals attain, in the proportions of their parts to one another, in their ornamentation, etc., and all the variations to which they are liable.

As soon as all the facts bearing upon these different points have been fully ascertained, there can remain no doubt respecting the natural limitation of species; and it is only the insatiable desire of describing new species from insufficient data which has led to the introduction in our systems of so many doubtful species, which add nothing to our real knowledge, and only go to swell the nomenclature of animals and plants already so intricate.

Assuming then, that species cannot always be identified at first sight, that it may require a long time and patient investigations to ascertain their natural limits; assuming further, that the features alluded to above are among the most prominent characteristics of species, we may say, that species are based upon well determined relations of individuals to the world around them, to their kindred, and upon the proportions and relations of their parts to one another, as well as upon their ornamentation. Well digested descriptions of species ought, therefore, to be comparative; they ought to assume the character of biographies, and attempt to trace the origin and follow the development of a species during its whole existence. Moreover, all the changes which species may undergo in course of time, especially under the fostering care of man, in the state of domesticity and cultivation, belong to the history of the species; even the anomalies and diseases to which they are subject, belong to their cycle, as well as their natural variations. Among some species, variation of color is frequent, others never change, some change periodically, others accidentally; some throw off certain ornamental appendages at regular times, the Deers their horns, some Birds the ornamental plumage they wear in the breeding season, etc. All this should be ascertained for each, and no species can be considered as well defined and satisfactorily characterized, the whole history of which is not completed to the extent alluded to above. The practice prevailing since Linnæus of limiting the characteristics of species to mere diagnoses, has led to the present confusion of our nomenclature, and made it often impossible to ascertain what were the species the authors of such condensed descriptions had before them. But for the tradition which has transmitted, generation after generation, the knowledge of these species among the cultivators of science in Europe, this confusion would be still greater; but for the preservation of most original collections it would be inextricable. In countries, which, like America, do not enjoy these advantages, it is often hopeless to attempt critical investigations upon doubtful cases of this kind. One of our ablest and most critical investigators, the lamented Dr. Harris, has very forcibly set forth the difficulties under which American naturalists labor in this respect, in the Preface to his Report upon the Insects Injurious to Vegetation.

SECTION VII.

OTHER NATURAL DIVISIONS AMONG ANIMALS.

Thus far I have considered only those kinds of divisions which are introduced in almost all our modern classifications, and attempted to show that these groups are founded in nature and ought not to be considered as artificial devices, invented by man to facilitate his studies. Upon the closest scrutiny of the subject, I find that these divisions cover all the categories of relationship which exist among animals, as far as their structure is concerned.

Branches or *types* are characterized by the plan of their structure,

Classes, by the manner in which that plan is executed, as far as ways and means are concerned,

Orders, by the degrees of complication of that structure,

Families, by their form, as far as determined by structure,

Genera, by the details of the execution in special parts, and

Species, by the relations of individuals to one another and to the world in which they live, as well as by the proportions of their parts, their ornamentation, etc.

And yet there are other natural divisions which must be acknowledged in a natural zoölogical system; but these are not to be traced so uniformly in all classes as the former,—they are in reality only limitations of the other kinds of divisions.

A class in which one system of organs may present a peculiar development, while all the other systems coincide, may be subdivided into sub-classes; for instance, the Marsupialia when contrasted with the Placental Mammalia. The characters upon which such a subdivision is founded, are of the kind upon which the class itself is based, but do not extend to the whole class. An order may embrace natural groups, of a higher value than families, founded upon ordinal characters, which may yet not determine absolute superiority or inferiority, and therefore not constitute for themselves distinct orders; as the characters upon which they are founded, though of the kind which determines orders, may be so blended as to determine superiority in one respect, while with reference to some other features they may indicate inferiority. Such groups are called sub-orders. The order of Testudinata, which I shall consider more in detail in the second part of this volume, may best illustrate this point, as it contains two natural sub-orders. A natural family may exhibit such modifications of its characteristic form, that upon these modifications subdivisions may be distinguished, which have been called sub-families by some authors, tribes or legions by others. In a natural genus, a number of species may agree more closely than others in the particulars which constitute the genus and lead to the distinction of sub-genera. The individuals of a species, occupying distinct fields of its natural geographical area, may differ somewhat from one another, and constitute varieties, etc.

These distinctions have long ago been introduced into our systems, and every practical naturalist, who has made a special study of any class of the animal kingdom, must have been impressed with the propriety of acknowledging a large number of subdivisions, to express all the various degrees of affinity of the different members of any higher natural group. Now, while I maintain that the branches, the classes, the orders, the families, the genera, and the species are groups established in nature respectively upon different categories, and while I feel prepared to trace the natural limits of these groups by the characteristic features upon which they are founded, I must confess at the same time that I have not yet been able to discover the principle which obtains in the limitation of their respective subdivisions. All I can say is, that all the different categories considered above, upon which branches, classes, orders, families, genera, and species are founded, have their degrees, and upon these degrees sub-classes, sub-orders, sub-families, and sub-genera have been established. For the present, these subdivisions must be left to arbitrary estimations, and we shall have to deal with them as well as we can, as long as the principles which regulate these degrees in the different kinds of groups are not ascertained. I hope, nevertheless, that such arbitrary estimations are for ever removed from our science, as far as the categories themselves are concerned.

Thus far, inequality of weight seems to be the standard of the internal valuation of each kind of group; and this inequality extends to all groups, for even within the branches there are classes more closely related among themselves than others: Polypi and Acalephs, for instance, stand nearer to one another than to Echinoderms; Crustacea and Insects are more closely allied to one another than to Worms, etc. Upon such degrees of relationship between the classes, within their respective branches, the so-called sub-types have been founded, and these differences have occasionally been exaggerated so far as to give rise to the establishment of distinct branches. Upon similar relations between the branches, sub-kingdoms have also been distinguished, but I hardly think that such far-fetched combinations can be considered as natural groups; they seem to me rather the expression of a relation arising from the weight of their whole organization, as compared with that of other groups, than the expression of a definite relationship.

SECTION VIII.

SUCCESSIVE DEVELOPMENT OF CHARACTERS.

It has been repeated, again and again, that the characters distinguishing the different types of the animal kingdom were developed in the embryo in the successive order of their importance: first the structural features of their respective branches, next the characters of the class, next those of the order, next those of the family, next those of the genus, and finally those of the species. This assertion has met with no direct opposition; on the contrary, it seems to have been approved almost without discussion, and to be generally taken for granted now. The importance of the subject requires, however, a closer scrutiny; for if Embryology is to lead to great improvements in Zoölogy, it is necessary, at the outset, to determine well what kind of information we may expect it to furnish to its sister science. Now I would ask if, at this day, zoölogists know with sufficient precision what are typical, class, ordinal, family, generic, and specific characters, to be justified in maintaining that, in the progress of embryonic growth, the features which become successively prominent correspond to these characters and in the order of their subordination? I doubt it. I will say more: I am sure there is no such understanding about it among them, for if there was, they would already have perceived that this assumed coincidence, between the subordination of natural groups among full-grown animals and the successive stages of growth during their embryonic period of life, does not exist in nature. It is true, there are certain features in the embryonic development which may suggest the idea of a progress from a more general typical organization to its ultimate specialization, but it nowhere proceeds in that stereotyped order of succession, nor indeed even in a general way, in the manner thus assumed.

Let us see whether it is not possible to introduce more precision in this matter. Taking for granted that what I have said about the characteristics of the natural groups in the animal kingdom is correct, that we have, 1st, four great typical branches of the animal kingdom, characterized by different plans of structure; 2d, classes, characterized by the ways in which and the means with which these plans of structure are executed; 3d, orders, characterized by the degrees of simplicity or complication of that structure; 4th, families, characterized by differences of form, or by the structural peculiarities determining form; 5th, genera, characterized by ultimate peculiarities of structure in the parts of the body; 6th, species, characterized by relations and proportions of parts among themselves, and of the individuals to one another and to the surrounding mediums; we reach, finally, the individuals, which, for the time being, represent not only the species with all their varieties, and variations of age, sex, size, etc., but also the characteristic features of all the higher groups. We have thus, at one end of the series, the most comprehensive categories of the structure of animals, while at the other end we meet individual beings. Individuality on one side, the most extensive divisions of the animal kingdom on the other. Now, to begin our critical examination of the progress of life in its successive manifestations with the extremes, is it not plain, from all we know of Embryology, that individualization is the first requirement of all reproduction and multiplication, and that an individual germ, (or a number of them,) an ovarian egg, or a bud, is first formed and becomes distinct as an individual from the body of the parent, before it assumes either the characters of its great type or those of its class, order, etc.? This fact is of great significance, as showing the importance of individuality in nature. Next, it is true, we perceive generally the outlines of the plan of structure, before it becomes apparent in what manner that plan is to be carried out; the character of the type is marked out, in its most general features, before that of the class can be recognized with any degree of precision. Upon this fact, we may base one of the most important generalizations in Embryology.

It has been maintained, in the most general terms, that the higher animals pass during their development through all the phases characteristic of the inferior classes. Put in this form, no statement can be further from the truth, and yet there are decided relations within certain limits, between the embryonic stages of growth of higher animals and the permanent characters of others of an inferior grade. Now the fact mentioned above, enables us to mark with precision the limits within which these relations may be traced. As eggs, in their primitive condition, animals do not differ one from the other; but as soon as the embryo has begun to show any characteristic features, it presents such peculiarities as distinguish its type. It cannot, therefore, be said that any animal passes through phases of development, which are not included within the limits of its own type; no Vertebrate is, or resembles, at any time an Articulate, no Articulate a Mollusk, no Mollusk a Radiate, and *vice versâ*. Whatever correlations between the young of higher animals and the perfect condition of inferior ones may be traced, they are always limited to representatives of the same great types; for instance, Mammalia and Birds, in their earlier development, exhibit certain features of the lower classes of Vertebrates, such as the Reptiles or Fishes; Insects recall the Worms in some of their earlier stages of growth, etc., but even this requires qualifications to which we shall have to refer hereafter. However, thus much is already evident, that no higher animal passes through phases of development recalling all the lower types of the animal kingdom, but only such as belong to its own branch. What has been said of the infusorial character of young embryos of Worms, Mollusks, and Radiates, can no longer stand before a serious criticism, because, in the first place, the animals generally called Infusoria cannot themselves be considered as a natural class; and in the second place, those to which a reference is made in this connection, are themselves free-moving embryos.[1]

With the progress of growth and in proportion as the type of an animal becomes more distinctly marked, in its embryonic state, the plan of structure appears also more distinctly in the peculiarities of that structure, that is to say, in the ways in which and the means by which the plan, only faintly indicated at first, is to be carried out and become prominent, and by this the class character is pointed out. For instance, a wormlike insect larva will already show, by its tracheæ, that it is to be an Insect and not to remain a Worm, as it at first appears to be; but the complications of that special structure, upon which the orders of the class of Insects are based, do not yet appear; this is perfected only at a late period in the embryonic life. At this stage, we frequently notice already a remarkable advance of the features characteristic of the families over those characteristic of the order; for instance, young Hemiptera, young Orthoptera may safely be referred to their respective families, from the characteristics they exhibit before they show those peculiarities which characterize them as Hemiptera or as Orthoptera; young Fishes may be known as members of their respective families before the characters of their orders are apparent, etc.

It is very obvious why this should be so. With the progress of the development of the structure, the general form is gradually sketched out, and it has already reached many of its most distinctive features, before all the complications of the structure which characterize the orders have become apparent; and as form characterizes essentially the families, we see here the reason why the family type

[1] See above, Chap. I., Sect. 18, p. 75.

may be fully stamped upon an animal before its ordinal characters are developed. Even specific characters, as far as they depend upon the proportions of parts and have on that ground an influence in modifying the form, may be recognized long before the ordinal characters are fully developed. The Snapping-Turtle, for instance, exhibits its small crosslike sternum, its long tail, its ferocious habits even before it leaves the egg, before it breathes through lungs, before its derm is ossified to form a bony shield, etc.; nay, it snaps with its gaping jaws at any thing brought near, though it be still surrounded by its amnios and allantois, and its yolk still exceeds in bulk its whole body.[1] The calf assumes the form of the bull before it bears the characteristics of the hollow-horned Ruminants; the fawn exhibits all the peculiarities of its species before those of its family are unfolded.

With reference to generic characters, it may be said that they are scarcely ever developed in any type of the animal kingdom, before the specific features are for the most part fully sketched out, if not completely developed. Can there be any doubt that the human embryo belongs to the genus Homo, even before it has cut a tooth? Is not a kitten, or a puppy distinguishable as a cat or a dog, before the claws and teeth tell their genus? Is this not true also of the Lamb, the Kid, the Colt, the Rabbits, and the Mice, of most Birds, most Reptiles, most Fishes, most Insects, Mollusks and Radiates? And why should this be? Simply, because the proportions of parts, which constitute specific characters, are recognizable before their ultimate structural development, which characterizes genera, is completed.

It seems to me that these facts are likely to influence the future progress of Zoölogy, in enabling us gradually to unravel more and more distinctly, the features which characterize the different subordinate groups of the animal kingdom. The views I have expressed above of the respective value and the prominent characteristics of these different groups, have stood so completely the test in this analysis of their successive appearance, that I consider this circumstance as adding to the probability of their correctness.

But this has another very important bearing, to which I have already alluded in the beginning of these remarks. Before Embryology can furnish the means of settling some of the most perplexing problems in Zoölogy, it is indispensable to ascertain first what are typical, classic, ordinal, family, generic, and specific characters; and as long as it could be supposed that these characters appear necessarily

[1] PR. M. v. NEU-WIED quotes as a remarkable fact, that the Chelonura serpentina bites as soon as it is hatched. I have seen it snapping in the same fierce manner as it does when full-grown, at a time it was still a pale, almost colorless embryo, wrapped up in its fœtal envelopes, with a yolk larger than itself hanging from its sternum, three months before hatching.

during the embryonic growth, in the order of their subordination, there was no possibility of deriving from embryological monographs, that information upon this point, so much needed in Zoölogy, and so seldom alluded to by embryologists. Again, without knowing what constitutes truly the characters of the groups named above, there is no possibility of finding out the true characters of a genus of which only one species is known, of a family which contains only one genus, etc., and for the same reason no possibility of arriving at congruent results with reference to the natural limitations of genera, families, orders, etc., without which we cannot even begin to build up a permanent classification of the animal kingdom; and still less, hope to establish a solid basis for a general comparison between the animals now living and those which have peopled the surface of our globe in past geological ages.

It is not accidentally I have been led to these investigations, but by necessity. As often as I tried to compare higher or more limited groups of animals of the present period with those of former ages, or early stages of growth of higher living animals with full-grown ones of lower types, I was constantly stopped in my progress by doubts as to the equality of the standards I was applying, until I made the standards themselves the object of direct and very extensive investigations, covering indeed a much wider ground than would appear from these remarks, for, upon these principles, I have already remodelled, for my own convenience, nearly the whole animal kingdom, and introduced in almost every class very unexpected changes in the classification.

I have already expressed above[1] my conviction that the only true system is that which exists in nature, and as, therefore, no one should have the ambition of erecting a system of his own, I will not even attempt now to present these results in the shape of a diagram, but remain satisfied to express my belief, that all we can really do is, at best, to offer imperfect translations in human language of the profound thoughts, the innumerable relations, the unfathomable meaning of the plan actually manifested in the natural objects themselves; and I should consider it as my highest reward should I find, after a number of years, that I had helped others on in the right path.

[1] See Chap. I., Sect. 1, p. 7–9.

SECTION IX.

CONCLUSIONS.

The importance of such an investigation as the preceding, must be obvious to every philosophical investigator. As soon as it is understood that all the different groups introduced into a natural system may have a definite meaning; as soon as it can be shown that each exhibits a definite relation among living beings, founded in nature, and no more subject to arbitrary modifications than any other law expressing natural phenomena; as soon as it is made plain that the natural limits of all these groups may be ascertained by careful investigations, the interest in the study of classification or the systematic relationship existing among all organized beings, which has almost ceased to engage the attention of the more careful original investigators, will be revived, and the manifold ties which link together all animals and plants, as the living expression of a gigantic conception, carried out in the course of time, like a soul-breathing epos, will be scrutinized anew, determined with greater precision, and expressed with increasing clearness and propriety. Fanciful and artificial classifications will gradually lose their hold upon a better informed community; scientific men themselves will be restrained from bringing forward immature and premature investigations; no characteristics of new species will have a claim upon the notice of the learned, which has not been fully investigated and compared with those most closely allied to it; no genus will be admitted, the structural peculiarities of which are not clearly and distinctly illustrated; no family will be considered as well founded, which shall not exhibit a distinct system of forms intimately combined and determined by structural relations; no order will appear admissible, which shall not represent a well-marked degree of structural complication; no class will deserve that name, which shall not appear as a distinct and independent expression of some general plan of structure, carried out in a peculiar way and with peculiar means; no type will be recognized as one of the fundamental groups of the animal kingdom, which shall not exhibit a plan of its own, not convertible into another. No naturalist will be justified in introducing any one of these groups into our systems without showing: 1st, that it is a natural group; 2d, that it is a group of this or that kind, to avoid, henceforth, calling families groups that may be genera, families groups that may be orders, classes or types groups that may be orders or classes; 3d, that the characters by which these groups may be recognized are in fact respectively specific, generic, family, ordinal, classic, or typical characters, so that our works shall no longer exhibit the annoying confusion, which is to be met almost everywhere, of generic characters in the diagnoses of species, or of family and ordinal characters in the characteristics of classes and types.[1]

It may perhaps be said, that all this will not render the study of Zoölogy more easy. I do not expect that it will; but if an attentive consideration of what I have stated in the preceding pages respecting classification, should lead to a more accurate investigation of all the different relations existing among animals, and between them and the world in which they live, I shall consider myself as having fully succeeded in the object I have had in view from the beginning, in this inquiry. Moreover, it is high time that certain zoölogists, who would call themselves investigators, should remember, that natural objects, to be fully understood, require more than a passing glance; they should imitate the example of astronomers, who have not become tired of looking into the relations of the few members of our solar system to determine, with increased precision, their motions, their size, their physical constitution, and keep in mind that every organized being, however simple in its structure, presents to our appreciation far more complicated phenomena, within our reach, than all the celestial bodies put together; they should remember, that as the great literary productions of past ages attract ever anew the attention of scholars, who can never feel that they have exhausted the inquiry into their depth and beauty, so the living works of God, which it is the proper sphere of Zoölogy to study, would never cease to present new attractions to them, should they proceed to the investigation with the right spirit. Their studies ought, indeed, inspire every one with due reverence and admiration for such wonderful productions.

The subject of classification in particular, which seems to embrace apparently so limited a field in the science of animals, cannot be rightly and fully understood without a comprehensive knowledge of all the topics alluded to in the preceding pages.

[1] As I do not wish to be personal, I will refrain from quoting examples to justify this assertion. I would only request those who care to be accurate, to examine critically almost any description of species, any characterization of genera, of families, of orders, of classes, and of types, to satisfy themselves that characters of the same kind are introduced almost indiscriminately to distinguish all these groups.

CHAPTER THIRD.

NOTICE OF THE PRINCIPAL SYSTEMS OF ZOÖLOGY.

SECTION I.

GENERAL REMARKS UPON MODERN SYSTEMS.

WITHOUT attempting to give an historical account of the leading features of all zoölogical systems, it is proper that I should here compare critically the practice of modern naturalists with the principles discussed above. With this view, it would hardly be necessary to go back beyond the publication of the "Animal Kingdom," by Cuvier, were it not that Cuvier is still represented, by many naturalists, and especially by Ehrenberg,[1] and some other German zoölogists, as favoring the division of the whole animal kingdom into two great groups, one containing the Vertebrates, and the other all the remaining classes, under the name of Invertebrates, while in reality it was he, who first, dismissing his own earlier views, introduced into the classification of the animal kingdom that fourfold division which has been the basis of all improvements in modern Zoölogy. He first showed that animals differ, not only by modifications of one and the same organic structure, but are constructed upon four different plans of structure, forming natural, distinct groups, which he called Radiata, Articulata, Mollusca, and Vertebrata.

It is true, that the further subdivisions of these leading groups have undergone many changes since the publication of the "Règne Animal." Many smaller groups, even entire classes, have been removed from one of his "embranchments" to another; but it is equally true, that the characteristic idea which lies at the bottom of these great divisions was first recognized by him, the greatest zoölogist of all times.

[1] EHRENBERG, (C. G.,) Die Corallenthiere des rothen Meeres, Berlin, 1834, 4to., p. 30.

The question which I would examine here in particular, is not whether the circumscription of these great groups was accurately defined by Cuvier, whether the minor groups referred to them truly belong there or elsewhere, nor how far these divisions may be improved within their respective limits, but whether there are four great fundamental groups in the animal kingdom, based upon four different plans of structure, and neither more nor less than four. This question is very seasonable, since modern zoölogists, and especially Siebold, Leuckart, and Vogt have proposed combinations of the classes of the animal kingdom into higher groups, differing essentially from those of Cuvier. It is but justice to Leuckart to say that he has exhibited, in the discussion of this subject, an acquaintance with the whole range of Invertebrata,[1] which demands a careful consideration of the changes he proposes, as they are based upon a critical discrimination of differences of great value, though I think he overrates their importance. The modifications introduced by Vogt, on the contrary, appear to me to be based upon entirely unphysiological principles, though seemingly borrowed from that all important guide, Embryology.

The divisions adopted by Leuckart are: Protozoa, (though he does not enter upon an elaborate consideration of that group,) Coelenterata, Echinodermata, Vermes, Arthropoda, Mollusca, and Vertebrata. The classification adopted, many years before, by Siebold, in his text-book of comparative anatomy, is nearly the same, except that Mollusks follow the Worms, that Coelenterata and Echinoderms are united into one group, and that the Bryozoa are left among the Polyps.

Here we have a real improvement upon the classification of Cuvier, inasmuch as the Worms are removed from among the Radiates, and brought nearer the Arthropods, an improvement however, which, so far as it is correct, has already been anticipated by many naturalists, since Blainville and other zoölogists long ago felt the impropriety of allowing them to remain among Radiates, and have been induced to associate them more or less closely with Articulates. But I believe the union of Bryozoa and Rotifera with the Worms, proposed by Leuckart, to be a great mistake; as to the separation of Coelenterata from Echinoderms, I consider it as an exaggeration of the difference which exists between Polyps and Acalephs on the one hand, and Echinoderms on the other.

The fundamental groups adopted by Vogt,[2] are: Protozoa, Radiata, Vermes, Mollusca, Cephalopoda, Articulata, and Vertebrata, an arrangement which is based solely upon the relations of the embryo to the yolk, or the absence of eggs. But, as

[1] Leuckart, (R.,) Ueber die Morphologie und die Verwandtschaftsverhältnisse der wirbellosen Thiere, Braunschweig, 1848, 1 vol., 8vo.

[2] Vogt, (Carl,) Zoologische Briefe. Naturgeschichte der lebenden und untergegangenen Thiere. Frankfurt a. M., 1851; vol. 1, p. 70.

I have already stated, this is an entirely unphysiological principle, inasmuch as it assumes a contrast between the yolk and the embryo, within limits which do not exist in nature. The Mammalia, for instance, which are placed, like all other Vertebrata, in the category of the animals in which there is an opposition between the embryo and the yolk, are as much formed of the whole yolk as the Echinoderms or Mollusks. The yolk undergoes a complete segmentation in Mammalia, as well as in Radiates or Worms, and most Mollusks; and the embryo when it makes its appearance no more stands out from the yolk, than the little Starfish stands out from its yolk. These simple facts, known since Sars and Bischoff published their first observations, twenty years ago, is in itself sufficient to show that the whole principle of classification of Vogt is radically wrong.

Respecting the assertion, that neither Infusoria nor Rhizopoda produce any eggs, I shall have more to say presently. As to the arrangement of the leading groups, Vertebrata, Articulata, Cephalopoda, Mollusca, Vermes, Radiata, and Protozoa in Vogt's system, it must be apparent to every zoölogist conversant with the natural affinities of animals, that a classification which interposes the whole series of Mollusks between the types of Articulata and Worms, cannot be correct. A classification based, like this, solely upon the changes which the yolk undergoes, is not likely to be the natural expression of the manifold relations existing between all animals. Indeed, no system can be true to nature, which is based upon the consideration of a single part, or a single organ.

After these general remarks, I have only to show more in detail, why I believe that there are only four great fundamental groups in the animal kingdom, neither more nor less.

With reference to Protozoa, first, it must be acknowledged that, notwithstanding the extensive investigation of modern writers upon Infusoria and Rhizopoda, the true nature of these beings is still very little known. The Rhizopoda have been wandering from one end of the series of Invertebrata to the other, without finding a place generally acknowledged as expressing their true affinities. The attempt to separate them from all the classes with which they have been so long associated, and to place them with the Infusoria in one distinct branch, appears to me as mistaken as any of the former arrangements, for I do not even consider that their animal nature is yet proved beyond a doubt, though I have myself once suggested the possibility of a definite relation between them and the lowest Gasteropods. Since it has been satisfactorily ascertained that the Corallines are genuine Algæ, which contain more or less lime in their structure, and since there is hardly any group among the lower animals and lower plants, which does not contain simple locomotive individuals, as well as compound communities, either free or adhering to the soil, I do not see that the facts known at present preclude the possibility of an association of the Rhizopods with the Algæ.[1] This would almost seem natural, when we consider that the vesicles of many Fuci contain a viscid, filamentous substance, so similar to that protruded from the body of the Rhizopods, that the most careful microscopic examination does not disclose the slightest difference in its structure from that which mainly forms the body of Rhizopods. The discovery by Schultze[2] of what he considers as the germinal granules of these beings, by no means settles this question, though we have similar ovoid masses in Algæ, and though, among the latter, locomotive forms are also very numerous.

With reference to the Infusoria, I have long since expressed my conviction that they are an unnatural combination of the most heterogeneous beings. A large number of them, the Desmidieæ and Volvocinæ, are locomotive Algæ. Indeed, recent investigations seem to have established beyond all question, the fact, that all the Infusoria Anentera of Ehrenberg are Algæ. The Enterodela, however, are true animals, but belong to two very distinct types, for the Vorticellidæ differ entirely from all others. Indeed, they are, in my opinion, the only independent animals of that group, and so far from having any natural affinity with the other Enterodela, I do not doubt that their true place is by the side of Bryozoa, among Mollusks, as I shall attempt to show presently. Isolated observations which I have been able to make upon Paramecium, Opalina, and the like, seem to me sufficient to justify the assumption that they disclose the true nature of the bulk of this group. I have seen, for instance, a Planaria lay eggs out of which Paramecium were born, which underwent all the changes these animals are known to undergo up to the time of their contraction into a chrysalis state; while the Opalina is hatched from Distoma eggs. I shall publish the details of these observations on another occasion. But if it can be shown that two such types as Paramecium and Opalina are the progeny of Worms, it seems to me to follow, that all the Enterodela, with the exception of the Vorticellidæ, must be considered as the embryonic condition of that host of Worms, both parasitic and free, the metamorphosis of which is still unstudied. In this connection, I might further remark, that the time is not long past when Cercaria was also considered as belonging to the class of Infusoria, though at present no one doubts that it belongs to the cycle of Distoma; and the only link in the metamorphosis of that genus which was not known is now supplied, since, as I have stated above, the embryo which is hatched from the egg laid by the perfect Distoma is found to be Opalina.

All this leads to the conclusion, that a division of the animal kingdom to be called Protozoa, differing from all other animals in producing no eggs, does not exist in nature, and that the beings which have been referred to it have now

[1] Comp. Chap. I., Sect. 18, p. 75.

[2] SCHULTZE, (M. S.,) Polythalamien, q. a.; p. 24.

to be divided, and scattered, partly among plants, in the class of Algæ, and partly among animals, in the classes of Acephala, (Vorticellæ,) of Worms, (Paramecium and Opalina,) and of Crustacea (Rotifera); Vorticellæ being genuine Bryozoa and therefore Acephalous Mollusks, while the beautiful investigations of Dana and Leydig have proved the Rotifera to be genuine Crustacea, and not Worms.

The great type of Radiata, taking its leading features only, was first recognized by Cuvier, though he associated with it many animals which do not properly belong to it. This arose partly from the imperfect knowledge of those animals at the time, but partly also from the fact that he allowed himself, in this instance, to deviate from his own principle of classification, according to which types are founded upon special plans of structure. With reference to Radiata, he departed, indeed, from this view, so far as to admit, besides the consideration of their peculiar plan, the element of simplicity of their structure as an essential feature in the typical character of these animals, in consequence of which he introduced five classes among Radiata: the Echinoderms, Intestinal Worms, Acalephs, Polypi, and Infusoria. In opposition to this unnatural association, I need not repeat here, what I have already stated of the Infusoria, when considering the case of Protozoa; neither is it necessary to urge again the propriety of removing the Worms from among Radiata, and connecting them with Articulata. There would thus remain only three classes among Radiates,—Polypi, Acalephs, and Echinoderms,—which, in my opinion, constitute really three natural classes in this great division, inasmuch as they exhibit the three different ways in which the characteristic plan of the type, radiation, is carried out, in distinct structures.

Since it can be shown that Echinoderms are, in a general way, homologous in their structure with Acalephs and Polypi, it must be admitted that these classes belong to one and the same great type, and that they are the only representatives of the branch of Radiata, assuming of course that Bryozoa, Corallinæ, Sponges, and all other foreign admixtures have been removed from among Polyps. Now, it is this Cuvierian type of Radiata, thus freed of all its heterogeneous elements, which Leuckart undertakes to divide into two branches, each of which he considers coequal with Worms, Articulates, Mollusks, and Vertebrates. He was undoubtedly led to this exaggeration of the difference existing between Echinoderms on one side and Acalephs and Polypi on the other, by the apparently greater resemblance of Medusæ and Polypi,[1] and perhaps still more by the fact, that so many genuine Acalephs, such as the Hydroids, including Tubularia, Sertularia, Campanularia, etc., are still comprised by most zoölogists in the class of Polypi.

[1] We see here clearly how the consideration of anatomical differences which characterize classes has overridden the primary feature of branches, their plan, to exalt a class to the rank of a branch.

But since the admirable investigations of J. Müller have made us familiar with the extraordinary metamorphosis of Echinoderms, and since the Ctenophoræ and the Siphonophoræ have also been more carefully studied by Grube, Leuckart, Kölliker, Vogt, Gegenbaur, and myself, the distance which seemed to separate Echinoderms from Acalephs disappears entirely, for it is no exaggeration to say, that were the Pluteus-like forms of Echinoderms not known to be an early stage in the transformation of Echinoderms, they would find as natural a place among Ctenophoræ, as the larvæ of Insects among Worms. I therefore maintain, that Polypi, Acalephs, and Echinoderms constitute one indivisible primary group of the animal kingdom. The Polypoid character of young Medusæ proves this as plainly as the Medusoid character of young Echinoderms.

Further, nothing can be more unnatural than the transfer of Ctenophoræ to the type of Mollusks which Vogt has proposed, for Ctenophoræ exhibit the closest homology with the other Medusæ, as I have shown in my paper on the Beroid Medusæ of Massachusetts. The Ctenophoroid character of young Echinoderms establishes a second connection between Ctenophoræ and the other Radiata, of as great importance as the first. We have thus an anatomical link to connect the Ctenophoræ with the genuine Medusæ, and an embryological link to connect them with the Echinoderms.

The classification of Radiata may, therefore, stand thus:—

1st Class: Polypi; including two orders, the Actinoids and the Halcyonoids, as limited by Dana.

2d Class: Acalephae; with the following orders: Hydroids, (including Siphonophoræ,) Discophoræ, and Ctenophoræ.

3d Class: Echinoderms; with Crinoids, Asteroids, Echinoids, and Holothurioids, as orders.

The natural limits of the branch of Mollusks are easily determined. Since the Cirripeds have been removed to the branch of Articulata, naturalists have generally agreed to consider, with Cuvier, the Cephalopods, Pteropods, Gasteropods, and Acephala as forming the bulk of this type, and the discrepancies between modern investigators have mainly resulted from the views they have taken respecting the Bryozoa, which some consider still as Polyps, while others would unite them with the Worms, though their affinity with the Mollusks seems to me to have been clearly demonstrated by the investigations of Milne-Edwards. Vogt is the only naturalist who considers the Cephalopoda "as built upon a plan entirely peculiar;"[1] though he does not show in what this peculiarity of plan consists, but only mentions the well-known anatomical differences which distinguish them from the other classes

[1] VOGT, (C.,) Zoologische Briefe, q. a.; vol. 1, p. 361.

of the branch of Mollusks. These differences, however, constitute only class characters and exhibit in no way a different plan. It is, indeed, by no means difficult to homologize all the systems of organs of the Cephalopods with those of the other Mollusks; and with this evidence, the proof is also furnished that the Cephalopods constitute only a class among the Mollusks.

As to the differences in the development of the Cephalopods and the other Mollusks, the type of Vertebrata teaches us that partial and total segmentation of the yolk are not inconsistent with unity of type, as the eggs of Mammalia and Cyclostomata undergo a total segmentation, while the process of segmentation is more or less limited in the other classes. In Birds, Reptiles, and Selachians, the segmentation is only superficial; in Batrachians, and most Fishes, it is much deeper; and yet no one would venture to separate the Vertebrata into several distinct branches on that account. With reference to Bryozoa, there can be no doubt, that their association with Polypi or with Worms is contrary to their natural affinities. The plan of their structure is in no way radiate; it is, on the contrary, distinctly and essentially bilateral; and as soon as their close affinities with the Brachiopods, alluded to above,[1] are fully understood, no doubt will remain of their true relation to Mollusks. As it is not within the limits of my plan to illustrate here the characters of all the classes of the animal kingdom, I will only state further, that the branch of Mollusks appears to me to contain only three classes, as follows: —

1st Class: Acephala; with four orders, Bryozoa, including the Vorticellæ, Brachiopods, Tunicata, and Lamellibranchiata.

2d Class: Gasteropoda; with three orders, Pteropoda, Heteropoda, and Gasteropoda proper.

3d Class: Cephalopoda; with two orders, Tetrabranchiata and Dibranchiata.

The most objectionable modification introduced in the general classification of the animal kingdom, since the appearance of Cuvier's Règne Animal, seems to me to be the establishment of a distinct branch, now very generally admitted under the name of VERMES, including the Annulata, the Helminths, the Rotifera, and as Leuckardt would have it, the Bryozoa also. It was certainly an improvement upon Cuvier's system, to remove the Helminths from the type of Radiates, but it was at the same time as truly a retrograde step to separate the Annelides from the branch of Articulata. The most minute comparison does not lead to the discovery of a distinct plan of structure, uniting all these animals into one natural primary group. What holds them together and keeps them at a distance[2] from other groups is not a common plan of structure, but a greater simplicity in their

[1] Chap. I., Sect. 18, p. 72.

[2] Chap. II., Sect. 7, p. 171, 172.

organization.[1] In bringing these animals together, naturalists make again the same mistake which Cuvier committed, when he associated the Helminths with the Radiates, only in another way and upon a greater scale.[2] The Bryozoa are as it were depauperated Mollusks, as Aphanes and Alchemilla are depauperated Rosaceæ. Rotifera are in the same sense the lowest Crustacea; while Helminths and Annelides constitute together the lowest class of Articulata. This class is connected by the closest homology with the larval states of Insects; the plan of their structure is identical, and there exists between them only such structural differences as constitute classes.[3] Moreover, the Helminths are linked to the Annelides in the same manner as the apodal larvæ of Insects are to the most highly organized caterpillars. It may truly be said that the class of Worms represents, in perfect animals, the embryonic states of the higher Articulata. The two other classes of this branch are the Crustacea and the Insects, respecting the limits of which, as much has already been said above,[4] as is necessary to state here.

The classification of the branch of Articulata may, therefore, stand thus:—

1st Class: Worms; with three orders, Trematods, (including Cestods, Planariæ, and Leeches,) Nematoids, (including Acanthocephala and Gordiacei,) and Annelides.

2d Class: Crustacea; with four orders, Rotifera, Entomostraca, (including Cirripeds,) Tetradecapods, and Decapods.

3d Class: Insects; with three orders, Myriapods, Arachnids, and Insects proper.

There is not a dissenting voice among anatomists respecting the natural limits of the Vertebrata, as a branch of the animal kingdom. Their character, however, does not so much consist in the structure of their backbone or the presence of a dorsal cord, as in the general plan of that structure, which exhibits a cavity above and a cavity below a solid axis. These two cavities are circumscribed by complicated arches, arising from the axis, which are made up of different systems of organs, the skeleton, the muscles, vessels, and nerves, and include, the upper one the centres of the nervous system, the lower one the different systems of organs by which assimilation and reproduction are carried on.

The number and limits of the classes of this branch are not yet satisfactorily ascertained. At least, naturalists do not all agree about them. For my part, I believe that the Marsupialia cannot be separated from the Placental Mammalia, as a distinct class, since we observe, within the limits of another type of Vertebrata, the Selachians, which cannot be subdivided into classes, similar differences in the mode of development to those which exist between the Marsupials and the other

[1] See above, Chap. I., Sect. 18, p. 74–78.

[2] Compare Chap. II., Sect. 1, p. 142.

[3] Compare Chap. II., Sect. 2, p. 145.

[4] Compare Chap. I., Sect. 18, p. 78–80.

Mammalia. But I hold, at the same time, with other naturalists, that the Batrachia must be separated, as a class, from the true Reptiles, as the characters which distinguish them are of the kind upon which classes are founded. I am also satisfied that the differences which exist between the Selachians, (the Skates, Sharks, and Chimæræ,) are of the same kind as those which distinguish the Amphibians from the Reptiles proper, and justify, therefore, their separation, as a class, from the Fishes proper. I consider also the Cyclostomes as a distinct class, for similar reasons; but I am still doubtful whether the Ganoids should be separated also from the ordinary Fishes. This, however, cannot be decided until their embryological development has been thoroughly investigated, though I have already collected data which favor this view of the case. Should this expectation be realized, the branch of Vertebrata would contain the following classes:—

1st Class: Myzontes; with two orders, Myxinoids and Cyclostomes.

2d Class: Fishes proper; with two orders, Ctenoids and Cycloids.

3d Class: Ganoids; with three orders, Cœlacanths, Acipenseroids, and Sauroids; and doubtful, the Siluroids, Plectognaths, and Lophobranches.

4th Class: Selachians; with three orders, Chimæræ, Galeodes, and Batides.

5th Class: Amphibians; with three orders, Cæciliæ, Ichthyodi, and Anura.

6th Class: Reptiles; with four orders, Serpentes, Saurii, Rhizodontes, and Testudinata.

7th Class: Birds; with four orders, Natatores, Grallæ, Rasores, and Insessores, (including Scansores and Accipitres.)

8th Class: Mammalia; with three orders, Marsupialia, Herbivora, and Carnivora.

I shall avail myself of an early opportunity to investigate more fully how far these groups of Vertebrata exhibit such characters as distinguish classes, and I submit my present impressions upon this subject, rather as suggestions for further researches, than as matured results.

SECTION II.

EARLY ATTEMPTS TO CLASSIFY ANIMALS.

So few American naturalists have paid special attention to the classification of the animal kingdom in general, that I deem it necessary to allude to the different principles which, at different times, have guided zoölogists in their attempts to group animals according to their natural affinities. This will appear the more acceptable, I hope, since few of our libraries contain even the leading works of our science, and many zealous students are thus prevented from attempting to study what has thus far been done.

Science has begun, in the introduction of names, to designate natural groups of different value with the same vagueness which still prevails in ordinary language in the use of class, order, genus, family, species; taking them either as synonyms or substituting one for the other at random. Linnæus was the first to urge upon naturalists precision in the use of four kinds of groups in natural history, which he calls classes, orders, genera, and species.

Aristotle, and the ancient philosophers generally, distinguished only two kinds of groups among animals, γένος and εἶδος, (genus and species.) But the term genus had a most unequal meaning, applying at times indiscriminately to any extensive group of species, and designating even what we now call classes as well as any other minor group. In the sense of class, it is taken in the following case: λέγω δὲ γένος, οἷον ὄρνιθα, καὶ ἰχθῦν, (Arist. Hist. Anim., Lib. I., Chap. I.,) while εἶδος is generally used for species, as the following sentence shows: καὶ ἔστιν εἴδη πλείω ἰχθύων καὶ ὀρνίθων, though it has occasionally also a wider meaning. The sixth chapter of the same book, is the most important in the whole work of Aristotle upon this subject, as it shows to how many different kinds of groups the term γένος is applied. Here, he distinguishes between γένη μέγιστα and γένη μεγάλα and γένος shortly. Γένη δὲ μέγιστα τῶν ζώων, εἰς ἃ διαιρεῖται τἆλλα ζῶα, τάδ' ἐστίν· ἓν μὲν ὀρνίθων, ἓν δ' ἰχθύων, ἄλλο δὲ κήτους. Ἄλλο δὲ γένος ἐστὶ τὸ τῶν ὀστρακοδέρμων. . . . . Τῶν δὲ λοιπῶν ζώων οὐκ ἔστι τὰ γένη μεγάλα· οὐ γὰρ περιέχει πολλὰ εἴδη ἓν εἶδος, ... τὰ δ' ἔχει μὲν, ἀλλ' ἀνώνυμα. This is further insisted upon anew: τοῦ δὲ γένους τῶν τετραπόδων ζώων καὶ ζωοτόκων εἴδη μὲν εἰσι πολλὰ, ἀνώνυμα δὲ. Here εἶδος has evidently a wider meaning than our term species, and the accurate Scaliger translates it by *genus medium*, in contradistinction to γένος, which he renders by *genus summum*. Εἶδος, however, is generally used in the same sense as now, and Aristotle already considers fecundity as a specific character, when he says, of the Hemionos, that it is called so from its likeness to the Ass, and not because it is of the same species, for he adds, they copulate and propagate among themselves: αἳ καλοῦνται ἡμίονοι δι' ὁμοιότητα, οὐκ οὖσαι ἁπλῶς τὸ αὐτὸ εἶδος· καὶ γὰρ ὀχεύονται καὶ γεννῶνται ἐξ ἀλλήλων. In another passage it applies, however, to a group exactly identical with our modern genus Equus: ἐπεί ἐστιν ἕν τι γένος καὶ ἐπὶ τοῖς ἔχουσι χαίτην, λοφούροις καλουμένοις, οἷον ἵππῳ καὶ ὄνῳ καὶ ὀρεῖ καὶ γίννῳ καὶ ἵννῳ καὶ τοῖς ἐν Συρίᾳ καλουμέναις ἡμιόνοις.

Aristotle cannot be said to have proposed any regular classification. He speaks constantly of more or less extensive groups, under a common appellation, evidently considering them as natural divisions; but he nowhere expresses a conviction that these groups may be arranged methodically so as to exhibit the natural affinities of animals. Yet he frequently introduces his remarks respecting different animals in such an order and in such connections as clearly to indicate that he knew their relations. When speaking of Fishes, for instance, he never includes the Selachians.

After Aristotle, the systematic classification of animals makes no progress for two thousand years, until Linnæus introduces new distinctions and assigns a more precise meaning to the terms class, (*genus summum*,) order, (*genus intermedium*,) genus, (*genus proximum*,) and species, the two first of which are introduced by him for the first time as distinct groups, under these names, in the system of Zoölogy.

SECTION III.

PERIOD OF LINNÆUS.

When looking over the "Systema Naturæ" of Linnæus, taking as the standard of our appreciation even the twelfth edition, which is the last he edited himself, it is hardly possible, in our day, to realize how great was the influence of that work upon the progress of Zoölogy.[1] And yet it acted like magic upon the age, and stimulated to exertions far surpassing any thing that had been done in preceding centuries. Such a result must be ascribed partly to the circumstance that he was the first man who ever conceived distinctly the idea of expressing in a definite form, what he considered to be a system of nature, and partly also to the great comprehensiveness, simplicity, and clearness of his method. Discarding in his system every thing that could not easily be ascertained, he for the first time divided the animal kingdom into distinct classes, characterized by definite features; he also for the first time introduced orders into the system of Zoölogy besides genera and species, which had been vaguely distinguished before.[2] And though he did not even attempt to define the characteristics of these different kinds of groups, it is plain, from his numerous writings, that he considered them all as subdivisions of a successively more limited value, embracing a larger or smaller number of animals, agreeing in more or less comprehensive attributes. He expresses

[1] To appreciate correctly the successive improvements of the classification of Linnæus, we need only compare the first edition of the "Systema Naturæ," published in 1735, with the second, published in 1740, the sixth published in 1748, the tenth published in 1758, and the twelfth published in 1766, as they are the only editions he revised himself. The third is only a reprint of the first, the fourth and fifth are reprints of the second; the seventh, eighth, and ninth are reprints of the sixth; the eleventh is a reprint of the tenth; and the thirteenth, published after his death, by Gmelin, is a mere compilation, deserving little confidence.

[2] See above, Sect. 2, p. 188. The *γένη μέγιστα* of Aristotle correspond, however, to the classes of Linnæus; the *γένη μεγάλα* to his orders.

his views of these relations between classes, orders, genera, species, and varieties, by comparisons, in the following manner:—[1]

Classis.	*Ordo.*	*Genus.*	*Species.*	*Varietas.*
Genus summum.	Genus intermedium.	Genus proximum.	Species.	Individuum.
Provinciæ.	Territoria.	Parœciæ.	Pagi.	Domicilium.
Legiones.	Cohortes.	Manipuli.	Contubernia.	Miles.

His arrangement of the animal kingdom is presented in the following diagram, compiled from the twelfth edition, published in 1766.

CLASSIFICATION OF LINNÆUS.

CL. 1. Mammalia. *Ord.* Primates, Bruta, Feræ, Glires, Pecora, Belluæ, Cete.
CL. 2. Aves. *Ord.* Accipitres, Picæ, Anseres, Grallæ, Gallinæ, Passeres.
CL. 3. Amphibia. *Ord.* Reptiles, Serpentes, Nantes.
CL. 4. Pisces. *Ord.* Apodes, Jugulares, Thoracici, Abdominales.
CL. 5. Insecta. *Ord.* Coleoptera, Hemiptera, Lepidoptera, Neuroptera, Hymenoptera, Diptera, Aptera.
CL. 6. Vermes. *Ord.* Intestina, Mollusca, Testacea, Lithophyta, Zoophyta.

In the earlier editions, up to the tenth, the class of Mammalia was called Quadrupedia, and did not contain the Cetaceans, which were still included among the Fishes. There seems never to have existed any discrepancy among naturalists respecting the natural limits of the class of Birds, since it was first characterized by Linnæus, in a manner which excluded the Bats and referred them to the class of Mammalia. In the early editions of the "Systema Naturæ," the class of Reptiles embraces the same animals as in the systems of the most recent investigators; but since the tenth edition, it has been encumbered with the addition of the cartilaginous and semicartilaginous Fishes, a retrograde movement suggested by some inaccurate observations of Dr. Garden. The class of Fishes is very well limited in the early editions of the Systema, with the exception of the admission of the Cetaceans, (Plagiuri,) which were correctly referred to the class of Mammalia, in the tenth edition. In the later editions, however, the Cyclostoms, Plagiostoms, Chimæræ, Sturgeons, Lophioids, Discoboli, Gymnodonts, Sclerodermes, and Lophobranches are excluded from it and referred to the class of Reptiles. The class of Insects,[2] as limited by Linnæus, embraces not only what are now considered as

[1] See Systema Naturæ, 12th edit., p. 13.

[2] Aristotle divides this group more correctly than Linnæus, as he admits already two classes, (γένη μέγιστα) among them, the Malacostraca, (Crustacea,) and the Entoma, (Insects.) Hist. Anim., Chap. VI. He seems also to have understood correctly the natural limits of the classes of Mammalia and Reptiles, for he distinguishes the Viviparous and Oviparous Quadrupeds, and nowhere confounds Fishes with Reptiles. Ibid.

Insects proper, but also the Myriapods, the Arachnids, and the Crustacea; it corresponds more accurately to the division of Arthropoda of modern systematists. The class of Worms, the most heterogeneous of all, includes besides all Radiata or Zoophytes and the Mollusks of modern writers, also the Worms, intestinal and free, the Cirripeds, and one Fish, (Myxine.) It was left for Cuvier[1] to introduce order in this chaos.

Such is, with its excellences and short-comings, the classification which has given the most unexpected and unprecedented impulse to the study of Zoölogy. It is useful to remember how lately even so imperfect a performance could have so great an influence upon the progress of science, in order to understand why it is still possible that so much remains to be done in systematic Zoölogy. Nothing, indeed, can be more instructive to the student of Natural History, than a careful and minute comparison of the different editions of the "Systema Naturæ" of Linnæus, and of the works of Cuvier and other prominent zoölogists, in order to detect the methods by which real progress is made in our science.

Since the publication of the "Systema Naturæ" up to the time when Cuvier published the results of his anatomical investigations, all the attempts at new classifications were, after all, only modifications of the principles introduced by Linnæus in the systematic arrangement of animals. Even his opponents labored under the influence of his master spirit, and a critical comparison of the various systems which were proposed for the arrangement of single classes or of the whole animal kingdom shows that they were framed according to the same principles, namely, under the impression that animals were to be arranged together into classes, orders, genera, and species, according to their more or less close external resemblance. No sooner, however, had Cuvier presented to the scientific world his extensive researches into the internal structure of the whole animal kingdom, than naturalists vied with one another in their attempts to remodel the whole classification of animals, establishing new classes, new orders, new genera, describing new species, and introducing all manner of intermediate divisions and subdivisions under the name of families, tribes, sections, etc. Foremost in these attempts was Cuvier himself, and next to him Lamarck. It has, however, often happened that the divisions introduced by the latter under new names, were only translations into a more systematic form of the results Cuvier had himself obtained from his dissections and pointed out in his "Leçons sur l'anatomie comparée," as natural divisions, but without giving them distinct names. Cuvier himself beautifully expresses the

[1] It would be injustice to Aristotle not to mention that he understood already the relations of the animals united in one class by Linnæus, under the name of Worms, better than the great Swedish naturalist. Speaking, for instance, of the great genera or classes, he separates correctly the Cephalopods from the other Mollusks, under the name of Malakia. Hist. Anim., Lib. I., Chap. VI.

influence which his anatomical investigations had upon Zoölogy, and how the improvements in classification have contributed to advance comparative anatomy, when he says, in the preface to the "Règne Animal," page vi.: "Je dus donc, et cette obligation me prit un temps considérable, je dus faire marcher de front l'anatomie et la zoologie, les dissections et le classement; chercher dans mes premières remarques sur l'organisation, des distributions meilleures; m'en servir pour arriver à des remarques nouvelles; employer encore ces remarques à perfectionner les distributions; faire sortir enfin de cette fécondation mutuelle des deux sciences l'une par l'autre, un système zoologique propre à servir d'introducteur et de guide dans le champ de l'anatomie, et un corps de doctrine anatomique propre à servir de développement et d'explication au système zoologique."

Without entering into a detailed account of all that was done in this period towards improving the system of Zoölogy, it may suffice to say, that before the first decade of this century had passed, more than twice as many classes as Linnæus adopted had been characterized in this manner. These classes are: the Mollusks, Cirripeds, Crustacea, Arachnids, Annelids, Entozoa, (Intestinal Worms,) Zoophytes, Radiata, Polyps, and Infusoria. Cuvier[1] admitted at first only eight classes, Duméril[2] nine, Lamarck[3] eleven and afterwards fourteen. The Cephalopoda, Gasteropoda, and Acephala, first so named by Cuvier, are in the beginning considered by him as orders only in the class of Mollusks; the Echinoderms also, though for the first time circumscribed by him within their natural limits, constitute only an order of the class of Zoophytes, not to speak of the lowest animals, which, from want of knowledge of their internal structure, still remain in great confusion. In this rapid sketch of the farther subdivisions which the classes Insecta and Worms of Linnæus have undergone under the influence of Cuvier, I have not, of course, alluded to the important contributions made to our knowledge of isolated classes, by special writers, but limited my remarks to the works of those naturalists who have considered the subject upon the most extensive scale.

Thus far, no attempt had been made to combine the classes among themselves into more comprehensive divisions, under a higher point of view, beyond that of dividing the whole animal kingdom into Vertebrata and Invertebrata, a division which corresponds to that of Aristotle, into ζῶα ἔναιμα and ζῶα ἄναιμα. All efforts were rather directed towards establishing a natural series, from the lowest Infusoria up to Man; which, with many, soon became a favorite tendency, and ended by being presented as a scientific doctrine by Blainville.

[1] CUVIER, (G.,) Tableau élémentaire de l'Histoire naturelle des Animaux, Paris, 1798, 1 vol. 8vo.

[2] DUMÉRIL, (A. M. C.,) Zoologie analytique, etc., Paris, 1806, 1 vol. 8vo.

[3] LAMARCK, (J. B. DE,) Système des Animaux sans Vertèbres ou Tableau général, etc., Paris, 1801, 1 vol. 8vo.—Histoire naturelle des Animaux sans Vertèbres, etc., Paris, 1815–1822, 7 vols. 8vo.

SECTION IV.

PERIOD OF CUVIER, AND ANATOMICAL SYSTEMS.

The most important period in the history of Zoölogy begins, however, with the year 1812, when Cuvier laid before the Academy of Sciences in Paris the results of his investigations upon the more intimate relations of certain classes of the animal kingdom to one another,[1] which had satisfied him that all animals are constructed upon four different plans, or, as it were, cast in four different moulds. A more suggestive view of the subject never was presented before to the appreciation of investigators; and, though it has by no means as yet produced all the results which certainly are to flow from its further consideration, it has already led to the most unquestionable improvements which classification in general has made since the days of Aristotle, and, if I am not greatly mistaken, it is only in as far as that fundamental principle has been adhered to that the changes proposed in our systems, by later writers, have proved a real progress, and not as many retrograde steps.

This great principle, introduced into our science by Cuvier, is expressed by him in these memorable words: "Si l'on considère le règne animal d'après les principes que nous venons de poser, en se débarrassant des préjugés établis sur les divisions anciennement admises, en n'ayant égard qu'à l'organisation et à la nature des animaux, et non pas à leur grandeur, à leur utilité, au plus ou moins de connaissance que nous en avons, ni à toutes les autres circonstances accessoires, on trouvera qu'il existe quatre formes principales, quatre plans généraux, si l'on peut s'exprimer ainsi, d'après lesquels tous les animaux semblent avoir été modelés et dont les divisions ultérieures, de quelque titre que les naturalistes les aient décorées, ne sont que des modifications assez légères fondées sur le développement ou l'addition de quelques parties, qui ne changent rien à l'essence du plan."

It is therefore incredible to me how, in presence of such explicit expressions, Cuvier can be represented, as he is still occasionally, as favoring a division of the animal kingdom into Vertebrata and Invertebrata.[2] Cuvier, moreover, was the first to recognize practically the inequality of all the divisions he adopts in his system; and this constitutes further a great and important step, even though he may not have found the correct measure for all his groups. For we must remember that at the time he wrote, naturalists were bent upon establishing one con-

[1] Ann. du Muséum d'Histoire Naturelle, vol. xix., Paris, 1812.

[2] EHRENBERG, (C. G.,) Die Corallenthiere des rothen Meeres, Berlin, 1834, 4to., p. 30, note.

tinual uniform series to embrace all animals, between the links of which it was supposed there were no unequal intervals. The watchword of their school was: *Natura non facit saltum.* They called their system *la chaine des êtres.*

The views of Cuvier led him to the following arrangement of the animal kingdom:—

CLASSIFICATION OF CUVIER.[1]

First Branch. ANIMALIA VERTEBRATA.

- CL. 1. Mammalia. *Orders*: Bimana, Quadrumana, Carnivora, Marsupialia, Rodentia, Edentata, Pachydermata, Ruminantia, Cetacea.
- CL. 2. Birds. *Ord.* Accipitres, Passeres, Scansores, Gallinæ, Grallæ, Palmipedes.
- CL. 3. Reptilia. *Ord.* Chelonia, Sauria, Ophidia, Batrachia.
- CL. 4. Fishes. *1st Series*: Fishes proper. *Ord.* Acanthopterygii;—Abdominales, Subbrachii, Apodes;—Lophobranchii, Plectognathi; *2d Series*: Chondropterygii. *Ord.* Sturiones, Selachii, Cyclostomi.[2]

Second Branch. ANIMALIA MOLLUSCA.

- CL. 1. Cephalopoda. No subdivisions into orders or families.
- CL. 2. Pteropoda. No subdivisions into orders or families.
- CL. 3. Gasteropoda. *Ord.* Pulmonata, Nudibranchia, Inferobranchia, Tectibranchia, Heteropoda, Pectinibranchia, Tubulibranchia, Scutibranchia, Cyclobranchia.
- CL. 4. Acephala. *Ord.* Testacea, Tunicata.
- CL. 5. Brachiopoda. No subdivisions into orders or families.
- CL. 6. Cirrhopoda. No subdivisions into orders or families.

Third Branch. ANIMALIA ARTICULATA.

- CL. 1. Annelides. *Ord.* Tubicolæ, Dorsibranchiæ, Abranchiæ.
- CL. 2. Crustacea. *1st Section*: Malacostraca. *Ord.* Decapoda, Stomapoda, Amphipoda, Læmodipoda, Isopoda. *2d Section*: Entomostraca. *Ord.* Branchiopoda, Pœcilopoda, Trilobitæ.
- CL. 3. Arachnides. *Ord.* Pulmonariæ, Trachenariæ.
- CL. 4. Insects. *Ord.* Myriapoda, Thysanura, Parasita, Suctoria, Coleoptera, Orthoptera, Hemiptera, Neuroptera, Hymenoptera, Lepidoptera, Rhipiptera, Diptera.

Fourth Branch. ANIMALIA RADIATA.

- CL. 1. Echinoderms. *Ord.* Pedicellata, Apoda.
- CL. 2. Intestinal Worms. *Ord.* Nematoidea, (incl. Epizoa and Entozoa,) Parenchymatosa.
- CL. 3. Acalephae. *Ord.* Simplices, Hydrostaticæ.
- CL. 4. Polypi. (Including Anthozoa, Hydroids, Bryozoa, Corallinæ, and Spongiæ.) *Ord.* Carnosi, Gelatinosi, Polypiarii.
- CL. 5. Infusoria. *Ord.* Rotifera and Homogenea, (including Polygastrica and some Algæ.)

[1] Le Règne animal distribué d'après son organisation, Paris, 1829, 2de édit. 5 vols. 8vo. The classes of Crustacea, Arachnids, and Insecta have been elaborated by Latreille. For the successive modifications the classification of Cuvier has undergone, compare his Tableau élémentaire, q. a., p. 192, his paper, q. a., p. 193, and the first edition of the Règne animal, published in 1817, in 4 vols. 8vo.

[2] Comp. Règn. Anim., 2de édit., 2d vol., p. 128 and 383.

When we consider the zoölogical systems of the past century, that of Linnæus, for instance, and compare them with more recent ones, that of Cuvier, for example, we cannot overlook the fact, that even when discoveries have added little to our knowledge, the subject is treated in a different manner; not merely in consequence of the more extensive information respecting the internal structure of animals, but also respecting the gradation of the higher groups.

Linnæus had no divisions of a higher order than classes. Cuvier introduced, for the first time, four great divisions, which he called "*embranchemens*" or branches, under which he arranged his classes, of which he admitted three times as many as Linnæus had done.

Again, Linnæus divides his classes into orders; next, he introduces genera, and finally, species; and this he does systematically in the same gradation through all classes, so that each of his six classes is subdivided into orders, and these into genera with their species. Of families, as now understood, Linnæus knows nothing. The classification of Cuvier presents no such regularity in its framework. In some classes he proceeds, immediately after presenting their characteristics, to the enumeration of the genera they contain, without grouping them either into orders or families. In other classes, he admits orders under the head of the class, and then proceeds to the characteristics of the genera, while in others still, he admits under the class not only orders and families, placing always the family in a subordinate position to the order, but also a number of secondary divisions which he calls sections, divisions, tribes, etc., before he reaches the genera and species. With reference to the genera again, we find marked discrepancies in different classes. Sometimes a genus is to him an extensive group of species, widely differing one from the other, and of such genera he speaks as "grands genres;" others are limited in their extent, and contain homogeneous species without farther subdivisions, while still others are subdivided into what he calls sub-genera, and this is usually the case with his "great genera."

The gradation of divisions with Cuvier varies then with his classes, some classes containing only genera and species, and neither orders nor families nor any other subdivision. Others contain orders, families, and genera, and besides these, a variety of subdivisions of the most diversified extent and significance. This remarkable inequality between all the divisions of Cuvier is, no doubt, partly owing to the state of Zoölogy and of zoölogical museums at the time he wrote, and to his determination to admit into his work only such representatives of the animal kingdom as he could to a greater or less extent examine anatomically for himself; but it is also partly to be ascribed to his conviction, often expressed, that there is no such uniformity or regular serial gradation among animals as many naturalists attempted to introduce into their classifications.

CLASSIFICATION OF LAMARCK.

Histoire naturelle des Animaux sans vertèbres, etc., Paris, 1815–1822, 7 vols. 8vo. — A second edition with notes has been published by Messrs. DesHayes and Milne-Edwards, Paris, 1835–1843, 10 vols. 8vo. — For the successive modifications this classification has undergone, see also: Système des animaux sans vertèbres, etc., Paris, 1801, 8vo. — Philosophie zoologique, etc., Paris, 1809, 2 vols. 8vo. — Extrait du Cours de Zoologie du Muséum d'Histoire naturelle, etc., Paris, 1812, 8vo.

INVERTEBRATA.

I. APATHETIC ANIMALS.

- CL. 1. **Infusoria.** *Ord.* Nuda, Appendiculata.
- CL. 2. **Polypi.** *Ord.* Ciliati (Rotifera), Denudati (Hydroids), Vaginati (Anthozoa and Bryozoa), and Natantes (Crinoids, and some Halcyonoids.)
- CL. 3. **Radiaria.** *Ord.* Mollia (Acalephæ), Echinoderms, (including Holothuriæ and Actiniæ.)
- CL. 4. **Tunicata.** *Ord.* Bothryllaria (Compound Ascidians), Ascidia, (Simple Ascidians.)
- CL. 5. **Vermes.** *Ord.* Molles and Rigiduli (Intestinal Worms and Gordius), Hispiduli (Nais), Epizoariæ (Epizoa, Lernæans.)

} Do not feel, and move only by their excited irritability. No brain, nor elongated medullary mass; no senses; forms varied; rarely articulations.

II. SENSITIVE ANIMALS.

- CL. 6. **Insects.** (Hexapods.) *Ord.* Aptera, Diptera, Hemiptera, Lepidoptera, Hymenoptera, Nevroptera, Orthoptera, Coleoptera.
- CL. 7. **Arachnids.** *Ord.* Antennato-tracheales (Thysanura and Myriapoda), Exantennato-tracheales and Exantennato-branchiales (Arachnids proper.)
- CL. 8. **Crustacea.** *Ord.* Heterobranchia (Branchipoda, Isopoda, Amphipoda, Stomapoda) and Homobranchia (Decapoda.)
- CL. 9. **Annelids.** *Ord.* Apoda, Antennata, Sedentaria.
- CL. 10. **Cirripeds.** *Ord.* Sessilia and Pedunculata.
- CL. 11. **Conchifera.** *Ord.* Dimyaria, Monomyaria.
- CL. 12. **Mollusks.** *Ord.* Pteropoda, Gasteropoda, Trachelipoda, Cephalopoda, Heteropoda.

} Feel, but obtain from their sensations only perceptions of objects, a sort of simple ideas, which they are unable to combine to obtain complex ones. No vertebral column; a brain and mostly an elongated medullary mass; some distinct senses; muscles attached under the skin; form symmetrical, the parts being in pairs.

VERTEBRATA.

III. INTELLIGENT ANIMALS.

- CL. 13. **Fishes.**
- CL. 14. **Reptiles.**
- CL. 15. **Birds.**
- CL. 16. **Mammalia.**

} Feel; acquire preservable ideas; perform with them operations by which they obtain others; are intelligent in different degrees. A vertebral column; a brain and a spinal marrow; distinct senses; the muscles attached to the internal skeleton; form symmetrical, the parts being in pairs.

It is not easy to appreciate correctly the system of Lamarck, as it combines abstract conceptions with structural considerations, and an artificial endeavor to arrange all animals in continuous series. The primary subdivision of the animal kingdom into Invertebrata and Vertebrata[1] corresponds, as I have stated above, to

[1] See, above, Chap. 2, Sect. 1, p. 138.

that of *Anaima* and *Enaima* of Aristotle. The three leading groups designated under the name of Apathetic, Sensitive, and Intelligent animals, are an imitation of the four branches of Cuvier; but, far from resting upon such a definite idea as the *divisions* of Cuvier, which involve a special plan of structure, they are founded upon the assumption that the psychical faculties of animals present a serial gradation, which, when applied as a principle of classification, is certainly not admissible. To say that neither Infusoria, nor Polypi, nor Radiata, nor Tunicata, nor Worms feel, is certainly a very erroneous assertion. They manifest sensations quite as distinctly as many of the animals included in the second type which are called Sensitive. And as to the other assertion, that they move only by their excited irritability, we need only watch the Starfishes to be satisfied that their motions are determined by internal impulses and not by external excitation. Modern investigations have shown that most of them have a nervous system, and many even organs of senses.

The Sensitive animals are distinguished from the third type, the Intelligent animals, by the character of their sensations. It is stated, in respect to the Sensitive animals, that they obtain from their sensations only perceptions of objects, a sort of simple ideas which they are unable to combine so as to derive from them complex ones, while the Intelligent animals are said to obtain ideas which they may preserve, and to perform with them operations by which they arrive at new ideas. They are said to be Intelligent. Even now, fifty years after Lamarck made those assertions, I doubt whether it is possible to distinguish in that way between the sensations of the Fishes, for instance, and those of the Cephalopods. It is true, the structure of the animals called Sensitive and Intelligent by Lamarck differs greatly, but a large number of his Sensitive animals are constructed upon the same plan as many of those he includes among the Apathetic; they embrace, moreover, two different plans of structure, and animal psychology is certainly not so far advanced as to afford the least foundation for the distinctions here introduced.

Even from his own point of view, his arrangement of the classes is less perfect than he might have made it, as the Annelids stand nearer to the Worms than the Insects, and are very inferior to them. Having failed to perceive the value of the idea of plan, and having substituted for it that of a more or less complicated structure, Lamarck unites among his Apathetic animals, Radiates (the Polypi and Radiaria) with Mollusks, (the Tunicata,) and with Articulates (the Worms.) Among the Sensitive animals, he unites Articulates (the Insects, Arachnids, Crustacea, Annelids, and Cirripeds) with Mollusks (the Conchifera, and the Mollusks proper.) Among the Intelligent animals, he includes the ancient four classes of Vertebrates, the Fishes, Reptiles, Birds, and Mammalia.

CLASSIFICATION OF DE BLAINVILLE.[1]

1. *Sub-Kingdom. Artiomorpha or Artiozoaria.* Form bilateral.

First Type: OSTEOZOARIA. (Vertebrata.)

Sub-Type: *Vivipara.*

CL. 1. **Pilifera**, or Mammifera. 1st. Monadelphya. 2d. Didelphya.

Sub-Type: *Ovipara.*

CL. 2. **Pennifera**, or Aves.

CL. 3. **Squamifera**, or Reptilia.

CL. 4. **Nudipellifera**, or Amphibia.

CL. 5. **Pinnifera**, or Pisces.

Anosteozoaria.

Second Type: ENTOMOZOARIA. (Articulata.)

CL. 6. **Hexapoda.** (Insecta proprie sic dicta.)

CL. 7. **Octopoda.** (Arachnida.)

CL. 8. **Decapoda.** (Crustacea, Decapoda, and Limulus.)

CL. 9. **Heteropoda.** (Squilla, Entomostraca, and Epizoa.)

CL. 10. **Tetradecapoda.** (Amphipoda and Isopoda.)

CL. 11. **Myriapoda.**

CL. 12. **Chætopoda.** (Annelides.)

CL. 13. **Apoda.** (Hirudo, Cestoidea, Ascaris.)

Third Type: MALENTOZOARIA.

CL. 14. **Nematopoda.** (Cirripedia.)

CL. 15. **Polyplaxiphora.** (Chiton.)

Fourth Type: MALACOZOARIA. (Mollusca.)

CL. 16. **Cephalophora.** Dioïca, (Cephalopoda and Gasteropoda, p. p.) Hermaphrodita and Monoïca (Gasteropoda reliqua.)

CL. 17. **Acephalophora.** Palliobranchia (Brachiopoda), Lamellibranchia (Acephala), Heterobranchia (Ascidiæ.)

2. *Sub-Kingdom. Actinomorpha or Actinozoaria.* Form radiate.

CL. 18. **Annelidaria**, or Gastrophysaria (Sipunculus, etc.)

CL. 19. **Ceratodermaria.** (Echinodermata.)

CL. 20. **Arachnodermaria.** (Acalephæ.)

CL. 21. **Zoantharia.** (Actiniæ.)

CL. 22. **Polypiaria.** (Polypi tentaculis simplicibus), (Anthozoa and Bryozoa.)

CL. 23. **Zoophytaria.** (Polypi tentáculis compositis), (Halcyonoidea.)

3. *Sub-Kingdom. Heteromorpha or Heterozoaria.* Form irregular.

CL. 24. **Spongiaria.** (Spongiæ.)

CL. 25. **Monadaria.** (Infusoria.)

CL. 26. **Dendrolitharia.** (Corallinæ.)

The classification of de Blainville resembles those of Lamarck and Cuvier much more than a diagram of the three would lead us to suppose. The first of these systems is founded upon the idea that the animal kingdom forms one gradated

[1] De l'Organisation des Animaux, Paris, 1822, 1 vol. 8vo.

series; only that de Blainville inverts the order of Lamarck, beginning with the highest animals and ending with the lowest. With that idea is blended, to some extent, the view of Cuvier, that animals are framed upon different plans of structure; but so imperfectly has this view taken hold of de Blainville, that instead of recognizing at the outset these great plans, he allows the external form to be the leading idea upon which his primary divisions are founded, and thus he divides the animal kingdom into three sub-kingdoms: the first, including his Artiozoaria, with a bilateral form; the second, his Actinozoaria, with a radiated form, and the third, his Heterozoaria, with an irregular form (the Sponges, Infusoria, and Corallines.) The plan of structure is only introduced as a secondary consideration, upon which he establishes four types among the Artiozoaria: 1st. The Osteozoaria, corresponding to Cuvier's Vertebrata; 2d. The Entomozoaria, corresponding to Cuvier's Articulata; 3d. The Malentozoaria, which are a very artificial group, suggested only by the necessity of establishing a transition between the Articulata and Mollusca; 4th. The Malacozoaria, corresponding to Cuvier's Mollusca. The second sub-kingdom, Actinozoaria, corresponds to Cuvier's Radiata, while the third sub-kingdom, Heterozoaria, contains organized beings which for the most part do not belong to the animal kingdom. Such at least are his Spongiaria and Dendrolitharia, whilst his Monodaria answer to the old class of Infusoria, about which enough has already been said above. It is evident, that what is correct in this general arrangement is borrowed from Cuvier; but it is only justice to de Blainville to say, that in the limitation and arrangement of the classes, he has introduced some valuable improvements. Among Vertebrata, for instance, he has, for the first time, distinguished the class of Amphibia from the true Reptiles. He was also the first to remove the Intestinal Worms from among the Radiata to the Articulata; but the establishment of a distinct type for the Cirripedia and Chitons was a very mistaken conception. Notwithstanding some structural peculiarities, the Chitons are built essentially upon the same plan as the Mollusks of the class Gasteropoda, and the investigations, made not long after the publication of de Blainville's system, have left no doubt that Cirripedia are genuine Crustacea. The supposed transition between Articulata and Mollusks, which de Blainville attempted to establish with his type of Malentozoaria, certainly does not exist in nature.

If we apply to the classes of de Blainville the test introduced in the preceding chapter, it will be obvious that his Decapoda, Heteropoda, and Tetradecapoda partake more of the character of orders than of that of classes, whilst among Mollusks, his class Cephalophora certainly includes two classes, as he has himself acknowledged in his later works. Among Radiata his classes Zoantharia, Polypiaria, and Zoophytaria partake again of the character of orders and not of those of classes. One great objection to the system of de Blainville is, the useless introduction of so many new names for groups which had already been correctly limited and well named by his predecessors. He had, no doubt, a desirable object in view in doing this,—he wished to remove some incorrect names; but he extended his reform too far when he undertook to change those also which did not suit his system.

CLASSIFICATION OF EHRENBERG.

The characteristics of the following twenty-eight classes of animals, with a twenty-ninth for Man alone, are given more fully in the Transactions of the Academy of Berlin for 1836, in the paper q. a., p. 138.

1st Cycle: NATIONS. Mankind, constituting one distinct class, is characterized by the equable development of all systems of organs, in contradistinction of the

2d Cycle: ANIMALS, which are considered as characterized by the prominence of single systems. These are divided into:

A. Myeloneura.

I. NUTRIENTIA. Warm-blooded Vertebrata, taking care of their young.
- CL. 1. Mammalia.
- CL. 2. Birds.

II. ORPHANOZOA. Cold-blooded Vertebrata, taking no care of their young.
- Cl. 3. Amphibia.
- Cl. 4. Pisces.

B. Ganglioneura.

A. Sphygmozoa, Cordata.
Circulation marked by a heart or pulsating vessels.

III. ARTICULATA. Real articulation, marked by rows of ganglia and their ramifications.
- CL. 5. Insecta.
- CL. 6. Arachnoidea.
- CL. 7. Crustacea (including Entomostraca, Cirripedia, and Lernæa.)
- CL. 8. Annulata. (The genuine Annelids exclusive of Nais.)
- CL. 9. Somatotoma. (Naidina.)

IV. MOLLUSCA. No articulation. Ganglia dispersed.
- CL. 10. Cephalopoda.
- CL. 11. Pteropoda.
- CL. 12. Gasteropoda.
- CL. 13. Acephala.
- CL. 14. Brachiopoda.
- CL. 15. Tunicata. (Ascidiæ simplices.)
- CL. 16. Aggregata. (Ascidiæ compositæ.)

B. Asphycta, Vasculosa.
Vessels without pulsation.

V. TUBULATA. No real articulation. Intestine, a simple sac or tube.
- CL. 17. Bryozoa.
- CL. 18. Dimorphæa. (Hydroids.)
- CL. 19. Turbellaria. (Rhabdocœla: Derostoma, Turbella, Vortex.)
- CL. 20. Nematoidea. (Entozoa, with simple intestine; also Gordius and Anguillula.)
- CL. 21. Rotatoria.
- CL. 22. Echinoidea. (Echinus, Holothuria, Sipunculus.)

VI. RACEMIFERA. Intestine divided, or forked, radiating, dendritic, or racemose.
- CL. 23. Asteroidea.
- CL. 24. Acalephae.
- CL. 25. Anthozoa.
- CL. 26. Trematodea. (Entozoa with ramified intestine, also Cercaria.)
- CL. 27. Complanata. (Dendrocœla: Planaria, etc.)
- CL. 28. Polygastrica.

The system of Zoölogy, published by Ehrenberg in 1836, presents many new views in almost all its peculiarities. The most striking of its features is the principle laid down, that the type of development of animals is one and the same from Man to the Monad, implying a complete negation of the principle advocated by Cuvier, that the four primary divisions of the animal kingdom are characterized by different plans of structure. It is very natural that Ehrenberg, after having illustrated so fully and so beautifully as he did, the natural history of so many organized beings, which up to the publication of his investigations were generally considered as entirely homogeneous, after having shown how highly organized and complicated the internal structure of many of them is, after having proved the fallacy of the prevailing opinions respecting their origin, should have been led to the conviction that there is, after all, no essential difference between these animals, which were then regarded as the lowest, and those which were placed at the head of the animal creation. The investigator, who had just revealed to the astonished scientific world the complicated systems of organs which can be traced in the body of microscopically small Rotifera, must have been led irresistibly to the conclusion that all animals are equally perfect, and have assumed, as a natural consequence of the evidence he had obtained, that they stand on the same level with one another, as far as the complication of their structure is concerned. Yet the diagram of his own system shows, that he himself could not resist the internal evidence of their unequal structural endowment. Like all other naturalists, he places Mankind at one end of the animal kingdom, and such types as have always been considered as low, at the other end.

Man constitutes, in his opinion, an independent cycle, that of nations, in contradistinction to the cycle of animals, which he divides into MYELONEURA, those with nervous marrow (the Vertebrata,) and GANGLIONEURA, those with ganglia (the Invertebrata.) The Vertebrata he subdivides into *Nutricula*, those which take care of their young, and *Orphanozoa*, those which take no care of their young, though this is not strictly true, as there are many Fishes and Reptiles which provide as carefully for their young as some of the Birds and Mammalia, though they do it in another way. The Invertebrata are subdivided into *Sphygmozoa*, those which have a heart or pulsating vessels, and *Asphycta*, those in which the vessels do not pulsate. These two sections are further subdivided: the first, into Articulata with real articulations and rows of ganglia, and Mollusks without articulation and with dispersed ganglia: the second, into Tubulata with a simple intestine, and Raccemifera with a branching intestine. These characters, which Ehrenberg assigns to his leading divisions, imply necessarily the admission of a gradation among animals. He thus negatives, in the form in which he expresses the results of his investigations, the very principle he intends to illustrate by his diagram. The peculiar view of Ehrenberg, that all animals are equal in the perfection of their organization, might be justified, if it was qualified so as to imply a relative perfection, adapted in all to the end of their special mode of existence. As no one observer has contributed more extensively than Ehrenberg to make known the complicated structure of a host of living beings, which before him were almost universally believed to consist of a simple mass of homogeneous jelly, such a view would naturally be expected of him. But this qualified perfection is not what he means. He does not wish to convey the idea that all animals are equally perfect in their way, for he states distinctly that "Infusoria have the same sum of systems of organs as Man," and the whole of his system is intended to impress emphatically this view. The separation of Man from the animals, not merely as a class but as a still higher division, is especially maintained upon that ground.

The principle of classification adopted by Ehrenberg is purely anatomical; the idea of type is entirely set aside, as is shown by the respective position of his classes. The Myeloneura, it is true, correspond to the branch of Vertebrata, and the Sphygmozoa to the Articulata and Mollusca; but they are not brought together on the ground of the typical plan of their structure, but because the first have a spinal marrow and the other a heart or pulsating vessels with or without articulations of the body. In the division of Tubulata, it is still more evident how the plan of their structure is disregarded, as that section embraces Radiata, (the Echinoidea and the Dimorphæa,) Mollusca, (the Bryozoa,) and Articulata, (the Turbellaria, the Nematoidea, and the Rotatoria,) which are thus combined simply on the ground that they have vessels which do not pulsate, and that their intestine is a simple sac or tube. The Racemifera contain also animals constructed upon different plans, united on account of the peculiar structure of the intestine, which is either forked or radiating, dendritic or racemose.

The limitation of many of the classes proposed by Ehrenberg is quite objectionable, when tested by the principles discussed above. A large proportion of them are, indeed, founded upon ordinal characters only, and not upon class characters. This is particularly evident with the Rotatoria, the Somatotoma, the Turbellaria, the Nematoidea, the Trematodea, and the Complanata, all of which belong to the branch of Articulata. The Tunicata, the Aggregata, the Brachiopoda, and the Bryozoa are also only orders of the class Acephala. Before Echinoderms had been so extensively studied as of late, the separation of the Echinoidea from Asteroidea might have seemed justifiable; at the present day, it is totally inadmissible. Even Leuckart, who considers the Echinoderms as a distinct branch of the animal kingdom, insists upon the necessity of uniting them as a natural group. As to the Dimorphæa, they constitute a natural order of the class Acalephæ, which is generally known by the name of Hydroids.

CLASSIFICATION OF BURMEISTER.

The following diagram is compiled from the author's Geschichte der Schöpfung, Leipzig, 1843, 1 vol. 8vo.

Type I. IRREGULAR ANIMALS.

1st Subtype. CL. 1. Infusoria.

Type II. REGULAR ANIMALS.

2d Subtype. CL. 2. Polypina. *Ord.* Bryozoa, Anthozoa.

3d Subtype. CL. 3. Radiata. *Ord.* Acalephæ, Echinodermata, Scytodermata.

Type III. SYMMETRICAL ANIMALS.

4th Subtype. CL. 4. Mollusca. *Ord.* Perigymna (Tunicata); Cormopoda (Acephala); Brachiopoda, Cephalophora (Pteropoda and Gasteropoda); Cephalopoda.

5th Subtype. Arthrozoa.

CL. 5. Vermes. *Ord.* Helminthes, Trematodes, and Annulati.

CL. 6. Crustacea. 1°. Ostracoderma. *Ord.* Prothesmia (Cirripedia, Siphonostoma, and Rotatoria); Aspidostraca (Entomostraca: Lophyropoda, Phyllopoda, Pœcilopoda, Trilobitæ.) 2°. Malacostraca. *Ord.* Thoracostraca (Podophthalma); and Arthrostraca, (Edriophthalma.)

CL. 7. Arachnoda. *Ord.* Myriapoda, Arachnidæ.

CL. 8. Insecta. *Ord.* Rhynchota, Synistata, Antliata, Piezata, Glossata, Eleutherata.

6th Subtype. Osteozoa. (Vertebrata.)

CL. 9. Pisces.

CL. 10. Amphibia.

CL. 11. Aves.

CL. 12. Mammalia.

The general arrangement of the classification of Burmeister recalls that of de Blainville; only that the order is inverted. His three types correspond to the three subkingdoms of de Blainville: the Irregular Animals to the Heterozoaria, the Regular Animals to the Actinozoaria, and the Symmetrical Animals to the Artiozoaria; while his subtypes of the Symmetrical Animals correspond to the types de Blainville admits among his Artiozoaria, with this important improvement, however, that the Malentozoaria are suppressed. Burmeister reduces, unhappily, the whole branch of Mollusks to one single class. The Arthrozoa, on the contrary, in the investigation of which Burmeister has rendered eminent service to science, are presented in their true light. In his special works,[1] his classification of the Articulata is presented with more details. I have no doubt that the correct views he entertains respecting the standing of the Worms in the branch of Articulata are owing to his extensive acquaintance with the Crustacea and Insects, and their metamorphoses.

[1] These works are: Beiträge zur Naturgeschichte der *Rankenfüsser*, (*Cirripedia*.) Berlin, 1834, 1 vol. 4to. — Handbuch der Entomologie, Berlin, 1832–47, 5 vols. 8vo.; Engl. by W. E. Shuckard, London, 1836. — Die Organisation der Trilobiten, aus ihren lebenden Verwandten entwickelt, Berlin, 1843, 1 vol. 4to.; Engl. by the Ray Society, London, 1847, 1 vol. fol.

CLASSIFICATION OF OWEN.

The following diagram is compiled from R. OWEN's Lectures on the Comparative Anatomy and Physiology of the Invertebrate Animals, 2d edit., London, 1855, 1 vol. 8vo.

Province. VERTEBRATA. Myelencephala. (Owen.)

CL. Mammalia.
CL. Aves.
CL. Reptilia.
} The classes Mammalia, Aves, and Reptilia are not yet included in the second volume of the "Lectures," the only one relating to Vertebrata thus far published.

CL. Pisces. *Ord.* Dermopteri, Malacopteri, Pharyngognathi, Anacanthini, Acanthopteri, Plectognathi, Lophobranchii, Ganoidei, Protopteri, Holocephali, Plagiostomi.

Province. ARTICULATA. Homogangliata. (Owen.)

CL. Arachnida. *Ord.* Dermophysa, Trachearia, Pulmotrachearia, and Pulmonaria.

CL. Insecta. *Subclass:* Myriapoda. *Ord.* Chilognatha and Chilopoda. *Subclass:* Hexapoda. *Ord.* Aptera, Diptera, Lepidoptera, Hymenoptera, Homoptera, Strepsiptera, Nevroptera, Orthoptera, and Coleoptera.

CL. Crustacea. *Subclass:* Entomostraca. *Ord.* Trilobites, Xiphosura, Phyllopoda, Cladocera, Ostracopoda, Copepoda. *Subclass:* Malacostraca. 1°. Edriophthalma. *Ord.* Læmodipoda, Isopoda, Amphipoda. 2°. Podophthalma. *Ord.* Stomapoda, Decapoda.

CL. Epizoa. *Ord.* Cephaluna, Brachiuna, and Onchuna.

CL. Annellata. *Ord.* Suctoria, Terricola, Errantia, Tubicola.

CL. Cirripedia. *Ord.* Thoracica, Abdominalia, and Apoda.

Province. MOLLUSCA. Heterogangliata. (Owen.)

CL. Cephalopoda. *Ord.* Tetrabranchiata and Dibranchiata.

CL. Gasteropoda. A. Monœcia: *Ord.* Apneusta (Köll.), Nudibranchiata, Inferobranchiata, Tectibranchiata, Pulmonata. B. Diœcia. *Ord.* Nucleobranchiata, Tubulibranchiata, Cyclobranchiata, Scutibranchiata, and Pectinibranchiata.

CL. Pteropoda. *Ord.* Thecosomata and Gymnosomata.

CL. Lamellibranchiata. *Ord.* Monomyaria and Dimyaria.

CL. Brachiopoda. Only subdivided into families.

CL. Tunicata. *Ord.* Saccobranchiata and Tæniobranchiata.

Subprovince. RADIARIA.[1]

CL. Echinodermata. *Ord.* Crinoidea, Asteroidea, Echinoidea, Holothurioidea, and Sipunculoidea.

CL. Bryozoa. Only subdivided into families.

CL. Anthozoa. Only subdivided into families.

CL. Acalephae. *Ord.* Pulmograda, Ciliograda, and Physograda.

CL. Hydrozoa. Only subdivided into families.

Subprovince. ENTOZOA.

CL. Cœlelmintha. *Ord.* Gordiacea, Nematoidea, and Onchophora.

CL. Sterelmintha. *Ord.* Tænioidea, Trematoda, Acanthocephala.—Turbellaria.

Subprovince. INFUSORIA.

CL. Rotifera. Only subdivided into families.

CL. Polygastria. *Ord.* Astoma, Stomatoda.—Rhizopoda.

[1] In the first edition of the work quoted above, published in 1843, the three subprovinces, Radiaria, Entozoa, and Infusoria are considered as one subkingdom called Radiata, in contradistinction of the subkingdoms, Mollusca, Articulata, and Vertebrata, and that subkingdom is subdivided into two groups, *Nematoneura* and *Acrita*.

The classification with which Owen[1] introduces his "Lectures on Comparative Anatomy" is very instructive, as showing, more distinctly than other modern systems, the unfortunate ascendency which the consideration of the complication of structure has gained of late over the idea of plan. His provinces, it is true, correspond in the main to the branches of Cuvier, with this marked difference, however, that he does not recognize a distinct province of Radiata coequal with those of Mollusca, Articulata, and Vertebrata, but only admits Radiaria as a subprovince on a level with Entozoa and Infusoria. Here, the idea of simplicity of structure evidently prevails over that of plan, as the subprovinces Radiaria, Entozoa, and Infusoria embrace, besides true Radiata, the lowest types of two other branches, Mollusks and Articulates. On the other hand, his three subprovinces correspond to the first three types of von Siebold; the Infusoria[2] of Owen embracing the same animals as the Protozoa of Siebold, his Entozoa[3] the same as the Vermes, and his Radiaria the same as the Zoophyta, with the single exception that Owen refers the Annellata to the province of Articulata, whilst Siebold includes them among his Vermes. Beyond this the types of Mollusca and Articulata (Arthropoda) of the two distinguished anatomists entirely agree. The position assigned by Owen to the provinces Articulata and Mollusca, not one above the other, but side by side with one another,[4] is no doubt meant to express his conviction, that the complication of structure of these two types does not justify the idea that either of them stands higher or lower than the other; and this is perfectly correct.

Several groups, established by previous writers as families or orders, are here admitted as classes. His class EPIZOA, which is not to be confounded with that established by Nitzsch under the same name, corresponds exactly to the family called LERNÉES by Cuvier. His class HYDROZOA answers to the order HYDROIDA of Johnston, and is identical with the class called DIMORPHÆA by Ehrenberg. His class CŒLELMINTHA corresponds to the order of INTESTINAUX CAVITAIRES established

[1] I have given precedence to the classification of Owen over those of von Siebold and Stannius, Milne-Edwards, Leuckart, etc., because the first edition of the "Lectures on Comparative Anatomy" was published in 1843; but in estimating its features, as expressed in the preceding diagram, it should be borne in mind that, in the first edition, the classes alone are considered, and that the orders and families were only added to the second edition in 1855. I mention this simply to prevent the possibility of being understood as ascribing to Owen all those subdivisions of the classes, which he admits, and which do not appear in the systems considered before his.

[2] The Rhizopoda are considered as a group coequal to Rotifera and Polygastria, on p. 16 of the "Lectures," but on p. 59, they stand as a suborder of Polygastria.

[3] The Turbellaria are represented as an independent group, on p. 16, and referred as a suborder to the Trematoda, on p. 118.

[4] From want of room, I have been compelled, in reproducing the classification of Owen in the preceding diagram, to place his provinces Articulata and Mollusca one below the other upon my page; according to his views, they should stand on a level, side by side with one another.

by Cuvier, with the addition of Gordius; while his class STERELMINTHA has the same circumscription as the order INTESTINAUX PARENCHYMATEUX of Cuvier. Generally speaking, it should not be understood that the secondary divisions mentioned by the different authors, whose systems I have analyzed here, were established by them. They are frequently borrowed from the results obtained by special investigators of isolated classes. But it would lead me too far, to enter here into a discussion of all these details.

This growing resemblance of the modern systems of Zoölogy is a very favorable sign of our times. It would, indeed, be a great mistake to assume, that it is solely owing to the influence of different authors upon one another; it is, on the contrary, to a very great extent, the result of our better acquaintance with Nature. When investigators, at all conversant with the present state of our science, must possess nearly the same amount of knowledge, it is self-evident that their views can no longer differ so widely as they did when each was familiar only with a part of the subject. A deeper insight into the animal kingdom must, in the end, lead to the conviction that it is not the task of zoölogists to introduce order among animals, but that their highest aim should be simply to read the natural affinities which exist among them, so that the more nearly our knowledge embraces the whole field of investigation, the more closely will our opinions coincide.

As to the value of the classes adopted by Owen, I may further remark that recent investigations, of which he might have availed himself, have shown that the Cirripedia and his Epizoa are genuine Crustacea, and that the Entozoa can no longer be so widely separated from the Annellata as in his system. With reference to the other classes, I refer the reader to my criticism of older systems, and to the first section of this Chapter.

It is a great satisfaction for me to find that the views I have advocated in the preceding sections, respecting the natural relations of the leading groups of the animal kingdom, coincide so closely with the classification of that distinguished zoölogist, Milne-Edwards, lately presented by him as the expression of his present views of the natural affinities of animals. He is the only original investigator who has recently given his unqualified approbation to the primary divisions first proposed by Cuvier, admitting, of course, the rectifications among the group of secondary rank, rendered necessary by the progress of science, to which he has himself so largely contributed.

As to the classes adopted by Milne-Edwards, I have little to add to what I have already stated before, with reference to other classifications. Though no longer overruling the idea of plan, that of complication of structure has still too much influence with Milne-Edwards, inasmuch as it leads him to consider as classes, groups of animals which differ only in degree, and are therefore only orders.

Such are, no doubt, his classes of Molluscoids and those of Worms, besides the Myriapods and Arachnids. Respecting the Fishes, I refer to my remarks in the first section (p. 187) of this Chapter.

CLASSIFICATION OF MILNE-EDWARDS.

The following diagram is drawn from the author's Cours élémentaire d'Histoire naturelle, Paris, 1855, 1 vol. 12mo., 7th edit., in which he has presented the results of his latest investigations upon the classification of the Vertebrata and Articulata; the minor subdivisions of the Worms, Mollusks, and Zoophytes, however, are not considered in this work.[1]

I. OSTEOZOARIA, or VERTEBRATA.

Subbranch. *Allantoidians.*

CL. Mammalia. 1°. Monodelphya. *a.* Propria. *Ord.* Bimana, Quadrumana, Cheiroptera, Insectivora, Rodentia, Edentata, Carnivora, Amphibia, Pachydermata, Ruminantia. *b.* Pisciformia. *Ord.* Cetacea. 2°. Didelphya. *Ord.* Marsupialia, Monotremata.

CL. Birds. *Ord.* Rapaces, Passeres, Scansores, Gallinæ, Grallæ, and Palmipedes.

CL. Reptiles. *Ord.* Chelonia, Sauria, Ophidia.

Subbranch. *Anallantoidians.*

CL. Batrachians. *Ord.* Anura, Urodela, Perennibranchia, Cæciliæ.

CL. Fishes. 1°. Ossei. *Ord.* Acanthopterygii, Abdominales, Subbrachii, Apodes, Lophobranchii, and Plectognathi. 2°. Chondropterygii. *Ord.* Sturiones, Selachii, and Cyclostomi.

II. ENTOMOZOA, or ANNELLATA.

Subbranch. *Arthropoda.*

CL. Insecta. *Ord.* Coleoptera, Orthoptera, Nevroptera, Hymenoptera, Lepidoptera, Hemiptera, Diptera, Rhipiptera, Anoplura, and Thysanura.

CL. Myriapoda. *Ord.* Chilognatha and Chilopoda.

CL. Arachnids. *Ord.* Pulmonaria and Trachearia.

CL. Crustacea. 1°. Podophthalmia. *Ord.* Decapoda and Stomapoda. 2°. Edriophthalma. *Ord.* Amphipoda, Læmodipoda, and Isopoda. 3°. Branchiopoda. *Ord.* Ostrapoda, Phyllopoda, and Trilobitæ. 4°. Entomostraca. *Ord.* Copepoda, Cladocera, Siphonostoma, Lernæida, Cirripedia. 5°. Xiphosura.

Subbranch. *Vermes.*

CL. Annelids.

CL. Helminths.

CL. Turbellaria.

CL. Cestoidea.

CL. Rotatoria.

III. MALACOZOARIA, or MOLLUSCA.

Subbranch. *Mollusks proper.*

CL. Cephalopods.

CL. Pteropods.

CL. Gasteropods.

CL. Acephala.

Subbranch. *Molluscoids.*

CL. Tunicata.

CL. Bryozoa.

IV. ZOOPHYTES.

Subbranch. *Radiaria*, or *Radiata.*

CL. Echinoderms.

CL. Acalephs.

CL. Corallaria, or Polypi.

Subbranch. *Sarcodaria.*

CL. Infusoria.

CL. Spongiaria.

[1] Consult, for these, his recent papers upon Polyps, Mollusks, and Crustacea, in the Ann. des Sc. Nat.

CLASSIFICATION OF VON SIEBOLD AND STANNIUS.

This classification is adopted in the following work: SIEBOLD, (C. TH. V.,) and STANNIUS, (H.,) Lehrbuch der vergleichenden Anatomie, Berlin, 1845, 2 vols. 8vo. A second edition is now in press.

EVERTEBRATA.

I. PROTOZOA.

CL. 1. Infusoria. *Ord.* Astoma and Stomatoda.

CL. 2. Rhizopoda. *Ord.* Monosomatia and Polysomatia.

II. ZOOPHYTA.

CL. 3. Polypi. *Ord.* Anthozoa and Bryozoa.

CL. 4. Acalephae. *Ord.* Siphonophora, Discophora, Ctenophora.

CL. 5. Echinodermata. *Ord.* Crinoidea, Asteroidea, Echinoidea, Holothurioidea, and Sipunculoidea.

III. VERMES.

CL. 6. Helminthes. *Ord.* Cystici, Cestodes, Trematodes, Acanthocephali, Gordiacei, Nematodes. { Since the publication of the work quoted above, Siebold has introduced most important improvements in the classification of the Worms, and greatly increased our knowledge of these animals.

CL. 7. Turbellarii. *Ord.* Rhabdocœli, Dendrocœli.

CL. 8. Rotatorii. Not subdivided into orders.

CL. 9. Annulati. *Ord.* Apodes and Chætopodes.

IV. MOLLUSCA.

CL. 10. Acephala. *Ord.* Tunicata, Brachiopoda, Lamellibranchia.

CL. 11. Cephalophora, Meck., (Gasteropoda.) *Ord.* Pteropoda, Heteropoda, Gasteropoda.

CL. 12. Cephalopoda. Not subdivided into orders.

V. ARTHROPODA.

CL. 13. Crustacea. *Ord.* Cirripedia, Siphonostoma, Lophyropoda, Phyllopoda, Pœcilopoda, Læmodipoda, Isopoda, Amphipoda, Stomapoda, Decapoda, Myriapoda.

CL. 14. Arachnida. Orders without names.

CL. 15. Insecta. *a.* Ametabola. *Ord.* Aptera. *b.* Hemimetabola; *Ord.* Hemiptera, Orthoptera. *c.* Holometabola. *Ord.* Diptera, Lepidoptera, Hymenoptera, Strepsiptera, Nevroptera, and Coleoptera.

VERTEBRATA.

VI. VERTEBRATA.

CL. 16. Pisces. *Subclasses:* 1st. Leptocardii. 2d. Marsipobranchii. 3d. Elasmobranchii; *Ord.* Holocephali, Plagiostomi. 4th. Ganoidei; *Ord.* Chrondrostei, Holostei. 5th. Teleostei; *Ord.* Acanthopteri, Anacanthini, Pharyngognathi, Physostomi, Plectognathi, Lophobranchii. 6th. Dipnoi.

CL. 17. Reptilia. *Subclasses:* 1st. Dipnoa; *Ord.* Urodela, Batrachia, Gymnophiona. 2d. Monopnoa: *a.* Streptostylica; *Ord.* Ophidia, Sauria. *b.* Monimostylica; *Ord.* Chelonia, Crocodila.

CL. 18. Aves.

CL. 19. Mammalia.

} The subdivisions of the classes Pisces and Reptilia are taken from the second edition, published in 1854–1856, in which J. Müller's arrangement of the Fishes is adopted; that of the Reptiles is partly Stannius's own. The classes Aves and Mammalia, and the first volume of the second edition, are not yet out.

The most original feature of the classification of von Siebold is the adoption of the types Protozoa and Vermes, in the sense in which they are limited here. The type of Worms has grown out of the investigations of the helminthologists, who, too exclusively engaged with the parasitic Worms, have overlooked their relations to the other Articulata. On the other hand, the isolation in which most entomologists have remained from the zoölogists in general, has no doubt had its share in preventing an earlier thorough comparison of the Worms and the larval conditions of Insects, without which the identity of type of the Worms, Crustacea, and Insects can hardly be correctly appreciated. Concerning the classes[1] adopted by von Siebold and Stannius, I have nothing to remark that has not been said already.

CLASSIFICATION OF R. LEUCKART.

The classification of Leuckart is compiled from the following work: LEUCKART, (R.,) Ueber die Morphologie und die Verwandtschaftsverhältnisse der wirbellosen Thiere, Braunschweig, 1848, 1 vol. 8vo.

I. COELENTERATA, Lkt.
- CL. 1. **Polypi.** *Ord.* Anthozoa and Cylicozoa (Lucernaria.)
- CL. 2. **Acalephae.** *Ord.* Discophoræ and Ctenophoræ.

II. ECHINODERMATA, Lkt.
- CL. 3. **Pelmatozoa**, Lkt. *Ord.* Cystidea and Crinoidea.
- CL. 4. **Actinozoa**, Latr. *Ord.* Echinida and Asterida.
- CL. 5. **Scytodermata**, Brmst. *Ord.* Holothuriæ and Sipunculida.

III. VERMES.
- CL. 6. **Anenterati**, Lkt. *Ord.* Cestodes and Acanthocephali. (Helminthes, *Burm.*)
- CL. 7. **Apodes**, Lkt. *Ord.* Nemertini, Turbellarii, Trematodes, and Hirudinei. (Trematodes, *Burm.*)
- CL. 8. **Ciliati**, Lkt. *Ord.* Bryozoa and Rotiferi.
- CL. 9. **Annelides.** *Ord.* Nematodes, Lumbricini, and Branchiati. (Annulati, *Burm.*, excl. Nemertinis et Hirudineis.)

IV. ARTHROPODA.
- CL. 10. **Crustacea.** *Ord.* Entomostraca (Neusticopoda Car.) and Malacostraca.
- CL. 11. **Insecta.** *Ord.* Myriapoda, Arachnida, (Acera, Latr.,) and Hexapoda.

V. MOLLUSCA, Cuv. (Palliata, Nitzsch.)
- CL. 12. **Tunicata.** *Ord.* Ascidiæ (Tethyes Sav.) and Salpæ (Thalides Sav.) — Leuckart is somewhat inclined to consider the Tunicata not simply as a class, but even as another great type or branch, intermediate between Echinoderms and Worms.
- CL. 13. **Acephala.** *Ord.* Lamellibranchiata (Cormopoda Nitzsch, Pelecypoda Car.) and Brachiopoda.
- CL. 14. **Gasteropoda.** *Ord.* Heterobranchia, (Pteropoda, Inferobranchia, and Tectibranchia,) Dermatobranchia, (Gymnobranchia and Phlebenterata,) Heteropoda, Ctenobranchia, Pulmonata, and Cyclobranchia.
- CL. 15. **Cephalopoda.**

VI. VERTEBRATA. (Not considered.)

[1] The names of the types, Protozoa and Vermes, are older than their limitation in the classification of Siebold. That of Protozoa, first introduced by Goldfuss, has been used in various ways for nearly half a century, while that of Worms was first adopted by Linnæus, as a great division of the animal kingdom, but in a totally different sense.

I need not repeat here what I have already stated, in the first section, respecting the primary divisions adopted by Siebold and Leuckart. As to the classes, I may add that his three classes of Echinoderms exhibit only ordinal characters. Besides Birds and Cephalopods, there is not another class so well defined, and so little susceptible of being subdivided into minor divisions presenting any thing like class characters, as that of Echinoderms. Their systems of organs are so closely homological, (compare p. 183,) that the attempt here made by Leuckart, of subdividing them into three classes, can readily be shown to rest only upon the admission, as classes, of groups which exhibit only ordinal characters, namely, different degrees of complication of structure. With reference to the classes of Worms, the same is equally true, as shown above. The arrangement of these animals proposed by Burmeister is certainly more correct than those of von Siebold and of Leuckart, inasmuch as he refers already correctly the Rotifera to the class of Crustacea, and does not, like Leuckart, associate the Bryozoa with the Worms. I agree, however, with Leuckart respecting the propriety of removing the Nemertini and Hirudinei from among the true Annelides. Again, Burmeister appreciates also more correctly the position of the whole type of Worms, in referring them, with de Blainville, to the branch of Articulata.

The common fault of all the anatomical classifications which have been proposed since Cuvier consists, first, in having given up, to a greater or less extent, the fundamental idea of the plan of structure, so beautifully brought forward by Cuvier, and upon which he has insisted with increased confidence and more and more distinct consciousness, ever since 1812; and, second, in having allowed that of complication of structure frequently to take the precedence over the more general features of plan, which, to be correctly appreciated, require, it is true, a deeper insight into the structure of the whole animal kingdom than is needed merely for the investigation of anatomical characters in single types.

Yet, if we take a retrospective glance at these systems, and especially consider the most recent ones, it must be apparent to those who are conversant with the views now obtaining in our science, that, after a test of half a century, the idea of the existence of branches, characterized by different plans of structure, as expressing the true relations among animals, has prevailed over the idea of a gradated scale including all animals in one progressive series. When it is considered that this has taken place amidst the most conflicting views respecting classification, and even in the absence of any ruling principle, it must be acknowledged that this can be only owing to the internal truth of the views first propounded by Cuvier. We recognize in the classifications of Siebold, Leuckart, and others the triumph of the great conception of the French naturalist, even though their systems differ greatly from his, for the question whether there are four or more great plans, limited in this or any other way, is not a question of principle, but one involving only accuracy and penetration in the investigation; and I maintain that the first sketch of Cuvier, with all its imperfections of details, presents a picture of the essential relations existing among animals truer to nature than the seemingly more correct classifications of recent writers.

SECTION V.

PHYSIOPHILOSOPHICAL SYSTEMS.

About the time that Cuvier and the French naturalists were tracing the structure of the animal kingdom, and attempting to erect a natural system of Zoölogy upon this foundation, there arose in Germany a school of philosophy, under the lead of Schelling, which extended its powerful influence to all the departments of physical science. Oken, Kieser, Bojanus, Spix, Huschke, and Carus are the most eminent naturalists who applied the new philosophy to the study of Zoölogy. But no one identified his philosophical views so completely with his studies in natural history as Oken.

Now that the current is setting so strongly against every thing which recalls the German physiophilosophers and their doings, and it has become fashionable to speak ill of them, it is an imperative duty for the impartial reviewer of the history of science to show how great and how beneficial the influence of Oken has been upon the progress of science in general and of Zoölogy in particular. It is moreover easier, while borrowing his ideas, to sneer at his style and his nomenclature, than to discover the true meaning of what is left unexplained in his mostly paradoxical, sententious, or aphoristical expressions; but the man who has changed the whole method of illustrating comparative Osteology,—who has carefully investigated the embryology of the higher animals, at a time when few physiologists were paying any attention to the subject, who has classified the three kingdoms of nature upon principles wholly his own, who has perceived thousands of homologies and analogies among organized beings entirely overlooked before, who has published an extensive treatise of natural history containing a condensed account of all that was known at the time of its publication, who has conducted for twenty-five years the most extensive and most complete periodical review of the natural sciences ever published, in which every discovery made during a quarter of a century is faithfully recorded, the man who inspired every student with an ardent love for science, and with admiration for his teacher,—that man will never be forgotten, nor can the services he has rendered to science be overlooked, so long as thinking is connected with investigation.

CLASSIFICATION OF OKEN.

The following diagram of Oken's classification is compiled from his Allgemeine Naturgeschichte für alle Stände, Stuttgardt, 1833–1842, 14 vols. 8vo.; vol. 1, p. 5. The changes this system has undergone may be ascertained by comparing his Lehrbuch der Naturphilosophie, Iena, 1809–1811, 3 vols. 8vo.; 2d edit., Iena, 1831; 3d edit., Zürich, 1843; Engl. Ray Society, London, 1847, 1 vol. 8vo. — Lehrbuch der Naturgeschichte, Leipzig, 1813; Weimar, 1815 and 1825, 8vo. — Handbuch der Naturgeschichte zum Gebrauch bei Vorlesungen, Nürnberg, 1816–1820, 8vo. — Naturgeschichte für Schulen, Leipzig, 1820, 1 vol. 8vo., and various papers in the Isis.

1st Grade. INTESTINAL ANIMALS; also called *Body*-animals and *Touch*-animals. Only one cavity; no head with a brain, only the lowest sense perfect, intestines and skin organs, but no flesh, that is no bones, muscles, or nervous marrow = *Invertebrata.*

Characterized by the development of the vegetative systems of organs, which are those of digestion, circulation, and respiration. Hence —

Cycle I. *Digestive Animals.* = Radiata. Essential character: no development beyond an intestine.
- CL. 1. Infusoria, (Stomach animals.) Mouth with cilia only, to vibrate.
- CL. 2. Polypi, (Intestine animals.) Mouth with lips and tentacles, to seize.
- CL. 3. Acalephae, (Lacteal animals.) Body traversed by tubes similar to the lymphatic vessels.

Cycle II. *Circulative Animals.* = Mollusks. Essential character: intestine and vessels.
- CL. 4. Acephala, (Biauriculate animals.) Membranous heart with two auricles.
- CL. 5. Gasteropoda, (Uniauriculate animals.) Membranous heart with one auricle.
- CL. 6. Cephalopoda, (Bicardial animals.) Two hearts.

Cycle III. *Respirative Animals.* = Articulata. Essential character: intestine, vessels, and spiracles.
- CL. 7. Worms, (Skin animals.) Respire with the skin itself, or part of it, no articulated feet.
- CL. 8. Crustacea, (Branchial animals.) Gills or air tubes arising from the horny skin.
- CL. 9. Insects, (Tracheal animals.) Tracheæ internally, gills externally as wings.

2d Grade. FLESH ANIMALS; also called *Head*-animals. = *Vertebrata.* Two cavities of the body, surrounded by fleshy walls, (bones and muscles,) inclosing nervous marrow and intestines. Head with brain; higher senses developed. Characterized by the development of the animal systems, namely, the skeleton, the muscles, the nerves, and the senses.

Cycle IV. *Carnal Animals proper.* Senses not perfected.
- CL. 10. Fishes, (*Bone*-animals.) Skeleton predominating, very much broken up; muscles white, brain without gyri, tongue without bone, nose not perforated, ear concealed, eyes without lids.
- CL. 11. Reptiles, (*Muscle*-animals.) Muscles red, brain without convolutions, nose perforated, ear without external orifice, eyes immovable with imperfect lids.
- CL. 12. Birds, (*Nerve*-animals.) Brain with convolutions, ears open, eyes immovable, lids imperfect.

Cycle V. *Sensual Animals.* All anatomical systems, and the senses perfected.
- CL. 13. Mammalia, (*Sense*-animals.) Tongue and nose fleshy, ears open, mostly with a conch, eyes movable, with two distinct lids.

The principles laid down by Oken, of which this classification is the practical result for Zoölogy, may be summed up in the following manner: The grades or great types of Animals are determined by their anatomical systems, such as the body and head; or the intestines, and the flesh and senses. Hence two grades in the animal kingdom. Animals are, as it were, the dismembered body of man made alive. The classes of animals are the special representation in living forms of the anatomical systems of the highest being in creation.

Man is considered, in this system, not only as the key of the whole animal kingdom, but also as the standard measure of the organization of animals. There exists nothing in the animal kingdom which is not represented in higher combinations in Man. The existence of several distinct plans of structure among animals is virtually denied. They are all built after the pattern of Man; the differences among them consist only in their exhibiting either one system only, or a larger or smaller number of systems of organs of higher or lower physiological importance, developed either singly, or in connection with one another, in their body. The principles of classification of both Cuvier and Ehrenberg are here entirely negatived. The principle of Cuvier, who admits four different plans of structure in the animal kingdom, is, indeed, incompatible with the idea that all animals represent only the organs of Man. The principle of Ehrenberg, who considers all animals as equally perfect, is as completely irreconcilable with the assumption that all animals represent an unequal sum of organs; for, according to Oken, the body of animals is, as it were, the analyzed body of Man, the organs of which live singly, or in various combinations as independent animals. Each such combination constitutes a distinct class. The principle upon which the orders are founded has already been explained above, (Chap. II., Sect. III., p. 154.)

There is something very taking in the idea that Man is the standard of appreciation of all animal structures. But all the attempts which have thus far been made to apply it to the animal kingdom as it exists, must be considered as complete failures. In his different works, Oken has successively identified the systems of organs of Man with different groups of animals, and different authors, who have adopted the same principle of classification, have identified them in still different ways. The impracticability of such a scheme must be obvious to any one who has satisfied himself practically of the existence of different plans of structure in the organization of animals. Yet, the unsoundness of the general principle of the classifications of the physiophilosophers should not render us blind to all that is valuable in their special writings. The works of Oken in particular teem with original suggestions respecting the natural affinities of animals; and his thorough acquaintance with every investigation of his predecessors and contemporaries shows him to have been one of the most learned zoölogists of this century.

CLASSIFICATION OF FITZINGER.

This diagram is extracted from Fitzinger's Systema Reptilium, Vindobonæ, 1843, 1 vol. 8vo.

I. Provincia. EVERTEBRATA.
Animalia systematum anatomicorum vegetativorum gradum evolutionis exhibentia.

A. Gradus evolutionis systematum physiologicorum vegetativorum.

I. Circulus. GASTROZOA.
Evolutio systematis nutritionis.

a. Evolutio prævalens systematis digestionis.
CL. 1. Infusoria.

b. Evolutio prævalens systematis circulationis.
CL. 2. Zoophyta.

c. Evolutio prævalens systematis respirationis.
CL. 3. Acalephae.

II. Circulus. PHYSIOZOA.
Evolutio systematis generationis.
CL. 4. Vermes. CL. 5. Radiata. CL. 6. Annulata.

B. Gradus evolutionis systematum physiologicorum animalium.

III. Circulus. DERMATOZOA.
Evolutio systematis sensibilitatis.
CL. 7. Acephala. CL. 8. Cephalopoda. CL. 9. Mollusca.

IV. Circulus. ARTHROZOA.
Evolutio systematis motus.
CL. 10. Crustacea. CL. 11. Arachnoidea. CL. 12. Insecta.

II. Provincia. VERTEBRATA.
Animalia systematum anatomicorum animalium gradum evolutionis exhibentia.

A. Gradus evolutionis systematum physiologicorum vegetativorum.
a. Evolutio systematis nutritionis, simulque ossium: . . . CL. 13. Pisces.
b. Evolutio systematis generationis, simulque musculorum: CL. 14. Reptilia.

B. Gradus evolutionis systematum physiologicorum animalium.
c. Evolutio systematis sensibilitatis, simulque nervorum: CL. 15. Aves.
d. Evolutio systematis motus, simulque sensuum: . . . CL. 16. Mammalia.

The fundamental idea of the classification of Fitzinger is the same as that upon which Oken has based his system. The higher divisions, called by him provinces, grades, and cycles, as well as the classes and orders, are considered as representing either some combination of different systems of organs, or some particular system of organs, or some special organ. His two highest groups (provinces) are the Evertebrata and Vertebrata. The Evertebrata represent the systems of the vegetative organs, and the Vertebrata those of the animal organs, as the Gut-animals and the Flesh-animals of Oken. Instead, however, of adopting, like Oken, anatomical names for his divisions, Fitzinger employs those most generally in use. His subdivisions or grades of these two primary groups are based upon a repetition of the same differences, within their respective limits. The Invertebrata, in which the vegetative organs prevail, are contrasted with those in which the animal organs prevail, and the same distinction is again drawn among the Vertebrata. Each of these embraces two circles founded upon the development of one particular system of organs, etc. It cannot be expected that the systems founded upon such principles should present a closer agreement with one another than those which are based upon anatomical differences; yet I would ask, what becomes of the principle itself, if its advocates cannot even agree upon what anatomical systems of organs their classes are founded? According to Oken, the Mollusks (Acephala, Gasteropoda, and Cephalopoda) represent the system of circulation, at least in the last edition of his system he views them in that light, whilst Fitzinger considers them as representing the system of sensibility. Oken identifies the Articulata (Worms, Crustacea, and Insects) with the system of respiration, Fitzinger with that of motion, with the exception of the Worms, including Radiata, which he parallelizes with the system of reproduction, etc. Such discrepancies must shake all confidence in these systems, though they should not prevent us from noticing the happy comparisons and suggestions, to which the various attempts to classify the animal kingdom in this way have led their authors. It is almost superfluous to add, that, great as the disagreement is between the systems of different physiophilosophers, we find quite as striking discrepancies between the different editions of the system of the same author.

The principle of the subdivision of the classes among Invertebrata is here exemplified from the Radiata, (Echinodermata.) Each series contains three orders.

1st Series.	2d Series.	3d Series.
Evolutio prævalens systematis digestionis.	Evolutio prævalens systematis circulationis.	Evolutio prævalens systematis respirationis.
Asteroidea.	Echinodea.	Scytodermata (Holothurioids.)
1. Encrinoidea. 2. Comatulina. 3. Asterina.	1. Aprocta. 2. Echinina. 3. Spatangoidea.	1. Synaptoidea. 2. Holothurioidea. 3. Pentactoidea.

In Vertebrata, each class has five series and each series three orders; so in Mammalia, for example:—

1st Series.	2d Series.	3d Series.	4th Series.	5th Series.
Evolutio prævalens sensus tactus.	Evolutio prævalens sensus gustus.	Evolutio prævalens sensus olfactus.	Evolutio prævalens sensus auditus.	Evolutio prævalens sensus visus.
Cetacea.	Pachydermata.	Edentata.	Unguiculata.	Primates.
1. Balanodea.	1. Phocina.	1. Monotremata.	1. Glires.	1. Chiropteri.
2. Delphinodea.	2. Obesa.	2. Lipodonta.	2. Bruta.	2. Hemipitheci.
3. Sirenia.	3. Ruminantia.	3. Tardigrada.	3. Feræ.	3. Anthropomorphi.

Instead of considering the orders as founded upon a repetition of the characters of higher groups, as Oken would have it, Fitzinger adopts series, as founded upon that idea, and subdivides them further into orders, as above. These series, however, have still less reference to the systems of organs, which they are said to represent, than either the classes or the higher divisions of the animal kingdom. In these attempts to arrange minor groups of animals into natural series, no one can fail to perceive an effort to adapt the frames of our systems to the impression we receive from a careful examination of the natural relations of organized beings. Everywhere we notice such series; sometimes extending only over groups of species, at other times embracing many genera, entire families, nay, extending frequently to several families. Even the classes of the same branch may exhibit more or less distinctly such a serial gradation. But I have failed, thus far, to discover the principle to which such relations may be referred, as far as they do not rest upon complication of structure,[1] or upon the degree of superiority or inferiority of the features upon which the different kinds of groups are themselves founded. Analogy plays also into the series, but before the categories of analogy have been as carefully scrutinized as those of affinity, it is impossible to say within what limits this takes place.

CLASSIFICATION OF McLEAY.

The great merit of the system of McLeay,[2] and in my opinion it has no other claim to our consideration, consists in having called prominently the attention of naturalists to the difference between two kinds of relationship, almost universally confounded before: *affinity* and *analogy*. Analogy is shown to consist in the repetition of similar features in groups otherwise remote, as far as their anatomical characters are concerned, whilst affinity is based upon similarity in the structural relations. On account of the similarity of their locomotion, Bats, for instance, may be considered as analogous to Birds; Whales are analogous to Fishes on account of the similarity of their form and their aquatic mode of life; whilst both Bats and Whales are allied to one another and to other Mammalia on account of the identity of the most characteristic features of their structure. This important distinction cannot fail to lead to interesting results. Thus far, however, it has only produced fanciful comparisons from those who first traced it out. It is assumed, for instance, by McLeay, that all animals of one group must be analogous to

[1] Compare Chap. II., Sect. 3, p. 153.

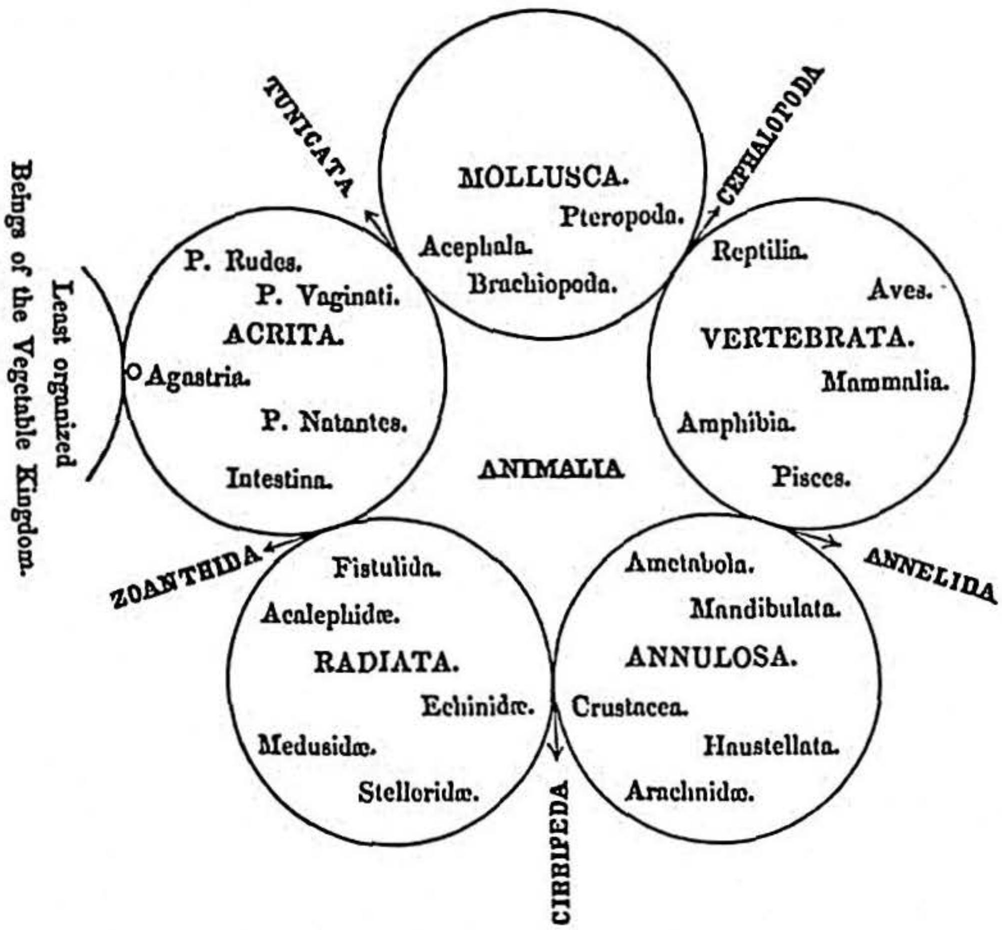
[2] I have introduced the classification of McLeay in this section, not because of any resemblance to those of the German physiophilosophers, but on account of its general character, and because it is based upon an ideal view of the affinities of animals.

those of every other group, besides forming a circle in themselves; and in order to carry out this idea, all animals are arranged in circular groups, in such a manner as to bring out these analogies, whilst the most obvious affinities are set aside to favor a preconceived view. But that I may not appear to underrate the merits of this system, I will present it in the very words of its most zealous admirer and self-complacent expounder, the learned William Swainson.[1]

"The Horæ Entomologicæ,[2] unluckily for students, can only be thoroughly understood by the adept, since the results and observations are explained in different parts; the style is somewhat desultory, and the groups, for the most part, are rather indicated than defined. The whole, in short, is what it professes to be, more a rough sketch of the leading peculiarities of the great divisions of animals, and the manner in which they are probably connected, than an accurate determination of the groups themselves, or a demonstration of their real affinities. More than this, perhaps, could not have been expected, considering the then state of science, and the herculean difficulties which the author had to surmount. The work in question has now become exceedingly scarce, and this will be an additional reason with us for communicating occasional extracts from it to the reader. Mr. McLeay's theory will be best understood by consulting his diagram; for he has not, as we have already remarked, defined any of the vertebrated groups. Condensing, however, the result of his remarks, we shall state them as resolvable into the following propositions: 1. That the natural series of animals is continuous, forming, as it were, a circle, so that, upon commencing at any one given point, and thence tracing all the modifications of structure, we shall be imperceptibly led, after passing through numerous forms, again to the point from which we started; 2. That no groups are natural which do not exhibit such a circular series; 3. That the primary divisions of every large group are ten, five of which are composed of comparatively large circles, and five of smaller: these latter being termed osculant, and being intermediate between the former, which they serve to connect; 4. That there is a tendency in such groups as are placed at the opposite points of a circle of affinity 'to meet each other;' 5. That *one* of the five larger groups into which every natural circle is divided, 'bears a resemblance to all the rest, or, more strictly speaking, consists of types which represent those of each of the four other groups, together with a type peculiar to itself.' These are the chief and leading principles which Mr. McLeay considers as belonging to the natural system. We shall now copy his diagram, or table of the animal kingdom, and then endeavor, with this help, to explain the system more in detail."

[1] SWAINSON, (W.,) A Treatise of the Geography and Classification of Animals, London, 1835, 1 vol. 12mo., p. 201–205.

[2] MCLEAY, (W. S.,) Horæ Entomologicæ, or Essays on the Annulose Animals, London, 1819–21, 2 vols. 8vo.



"We must, in the first instance, look to the above tabular disposition of all animals, as forming themselves collectively into one great circle, which circle touches or blends into another, composed of plants, by means of the 'least organized beings of the vegetable kingdom.' Next we are to look to the larger component parts of this great circular assemblage. We find it, in accordance with the third proposition, to exhibit five great circles, composed of the MOLLUSCA, or shellfish; ACRITA, or polyps; RADIATA, or star-fish; ANNULOSA, or insects; and VERTEBRATA, or vertebrated animals; each passing or blending into each other, by means of five other groups of animals, much smaller, indeed, in their extent, but forming so many connecting or osculant circles.[1] The number, therefore, as many erroneously suppose, is not five, but ten. This is quite obvious; and our opinion on this point is confirmed by the author himself, in the following passage, when alluding to his remarks upon the whole:—'The foregoing observations, I am well aware, are far from accurate, but they are sufficient to prove that there are five great circular groups in the animal kingdom, each of which possesses a peculiar structure; and that

[1] In the original diagram, as in that above, these five smaller circles are not represented graphically, but merely indicated by the names arranged like rays between the five large circles.

these, when connected by means of five smaller osculant groups, compose the whole province of Zoölogy.' Now these smaller osculant groups are to be viewed as circles, for, as it is elsewhere stated, 'every natural group is a circle, more or less complete.' This, in fact, is the third general principle of Mr. McLeay's system, and he has exemplified his meaning of a natural group in the above diagram, where all animals are arranged under five large groups or circles, and five smaller ones. Let us take one of these groups, the Vertebrata: does that form a circle of itself? Yes; because it is intimated that the Reptiles (*Reptilia*) pass into the Birds, (*Aves*,) these again into the Quadrupeds, (*Mammalia*,) Quadrupeds unite with the Fishes, (*Pisces*,) these latter with the amphibious Reptiles, and the Frogs bring us back again to the Reptiles, the point from whence we started. Thus, the series of the vertebrated group is marked out and shown to be circular; therefore, it is a natural group. This is an instance where the circular series can be traced. We now turn to one where the series is imperfect, but where there is a decided tendency to a circle: this is the Mollusca. Upon this group our author says, 'I have by no means determined the circular disposition to hold good among the Mollusca; still, as it is equally certain that this group of animals is as yet the least known, it may be improper, at present, to conclude that it forms any exception to the rule; it would even seem unquestionable that the Gasteropoda of Cuvier return into themselves, so as to form a circular group; but whether the Acephala form one or two such, is by no means accurately ascertained, though enough is known of the Mollusca to incline us to suspect that they are no less subjected, in general, to a circular disposition than the four other great groups.' This, therefore, our author considers as one of those groups which, without actually forming a circle, yet evinces a disposition to do so; and it is therefore presumed to be a natural group. But, to illustrate this principle farther, let us return to the circle of Vertebrata. This, as we see by the diagram, contains five minor groups, or circles, each of which is again resolvable into five others, regulated precisely in the same way. The class Aves, for example, is first divided into rapacious birds, (*Raptores*,) perching birds, (*Insessores*,) gallinaceous birds, (*Rasores*,) wading birds, (*Grallatores*,) and swimming birds (*Natatores*); and the proof of this class being a natural group is, in all these divisions blending into each other at their confines, and forming a circle. In this manner we proceed, beginning with the higher groups, and descending to the lower, until at length we descend to genera, properly so called, and reach, at last, the species; every group, whether large or small, forming a circle of its own. Thus there are circles within circles, 'wheels within wheels,'—an infinite number of complicated relations; but all regulated by one simple and uniform principle,—that is, the circularity of every group."

The writer who can see that the Quadrupeds unite with the Fishes, and the like, and yet says that Cuvier "was totally unacquainted with the very first principles of the natural system," hardly deserves to be studied in our days.

The attempt at representing graphically the complicated relations which exist among animals has, however, had one good result; it has checked, more and more, the confidence in the uniserial arrangement of animals, and led to the construction of many valuable maps exhibiting the multifarious relations which natural groups, of any rank, bear to one another.

SECTION VI.

EMBRYOLOGICAL SYSTEMS.

Embryology, in the form it has assumed within the last fifty years, is as completely a German science as the "Naturphilosophie." It awoke to this new activity contemporaneously with the development of the Philosophy of Nature. It would hardly be possible to recognize the leading spirit in this new development, from his published works; but the man whom Pander and K. E. von Baer acknowledge as their master must be considered as the soul of this movement, and this man is Ignatius Döllinger. It is with deep gratitude I remember, for my own part, the influence that learned and benevolent man had upon my studies and early scientific application, during the four years I spent in his house, in Munich, from 1827 to 1831; to him I am indebted for an acquaintance with what was then known of the development of animals, prior to the publication of the great work of Baer; and from his lectures I first learned to appreciate the importance of Embryology to Physiology and Zoölogy. The investigations of Pander[1] upon the development of the chicken in the egg, which have opened the series of those truly original researches in Embryology of which Germany may justly be proud, were made under the direction and with the coöperation of Döllinger, and were soon followed by the more extensive works of Rathke and Baer, whom the civilized world acknowledges as the founders of modern Embryology.

The principles of classification propounded by K. E. von Baer seem never to have been noticed by systematic writers, and yet they not only deserve the most careful consideration, but it may fairly be said that no naturalist besides Cuvier has exhibited so deep an insight into the true character of a natural system,

[1] PANDER, Beiträge zur Entwickelungsgeschichte des Hühnchens im Eie, Würzburg, 1817, 1 vol. fol.

supported by such an extensive acquaintance with the subject, as this great embryologist has in his "Scholien und Corallarien zu der Entwickelungsgeschichte des Hühnchens im Eie."[1] These principles are presented in the form of general propositions, rather than in the shape of a diagram with definite systematic names, and this may explain the neglect which it has experienced on the part of those who are better satisfied with words than with thoughts. A few abstracts, however, may show how richly the perusal of his work is likely to reward the reader.

The results at which K. E. von Baer had arrived by his embryological investigations, respecting the fundamental relations existing among animals, differed considerably from the ideas then prevailing. In order, therefore, to be correctly understood, he begins, with his accustomed accuracy and clearness, to present a condensed account of those opinions with which he disagreed, in these words:—

"Few views of the relations existing in the organic world have received so much approbation as this: that the higher animal forms, in the several stages of the development of the individual, from the beginning of its existence to its complete formation, correspond to the permanent forms in the animal series, and that the development of the several animals follows the same laws as those of the entire animal series; that consequently the more highly organized animal, in its individual development, passes in all that is essential through the stages that are permanent below it, so that the periodical differences of the individual may be reduced to the differences of the permanent animal forms."

Next, in order to have some standard of comparison with his embryological results, he discusses the relative position of the different permanent types of animals, as follows:—

"It is especially important that we should distinguish between the degree of perfection in the animal structure and the type of organization. The degree of perfection of the animal structure consists in the greater or less heterogeneousness of the elementary parts, and the separate divisions of a complicated apparatus,—in one word, in the greater histological and morphological differentiation. The more uniform the whole mass of the body is, the lower the degree of perfection; it is a stage higher when nerve and muscle, blood and cellular tissue, are sharply distinguished. In proportion to the difference between these parts, is the development of the animal life in its different tendencies; or, to express it more accurately, the more the animal life is developed in its several tendencies, the more heterogeneous are the elementary parts which this life brings into action. The same is true of the single parts of any apparatus. That organ-

[1] Ueber Entwickelungsgeschichte der Thiere, Beobachtung und Reflexion von Dr. Karl Ernst von Baer, Königsberg, 1828, 4to.—See also Acta Nova Acad. Leop. Cæsar, vol. 13, and Meckel's Arch., 1826.

ization is higher in which the separate parts of an entire system differ more among themselves, and each part has greater individuality, than that in which the whole is more uniform. I call type, the relations of organic elements and organs, as far as their position is concerned. This relation of position is the expression of certain fundamental connections in the tendency of the individual relations of life; as, for instance, of the receiving and discharging poles of the body. The type is altogether distinct from the degree of perfection, so that the same type may include many degrees of perfection, and, *vice versâ*, the same degree of perfection may be reached in several types. The degree of perfection, combined with the type, first determines those great animal groups which have been called classes.[1] The confounding of the degree of perfection with the type of organization seems the cause of much mistaken classification, and in the evident distinction between these two relations we have sufficient proof that the different animal forms do not present one uniserial development, from the Monad up to Man."

The types he has recognized are:—

I. *The Peripheric Type.* The essential contrasts in this type are between the centre and the periphery.[2] The organic functions of life are carried on in antagonistic relations from the centre to the circumference. Corresponding to this, the whole organization radiates around a common centre. There exists besides only the contrast between above and below, but in a weaker degree; that between right and left, or before and behind, is not at all noticeable, and the motion is therefore undetermined in its direction. As the whole organization radiates from one focus, so are the centres of all the organic systems arranged, ring-like, around it, as, for instance, the stomach, the nerves and vessels, (if these parts are developed,) and the branches extending from them into the rays. What we find in one ray is repeated in every other, the radiation being always from the centre outwards, and every ray bearing the same relation to it.

II. *The Longitudinal Type,* as observed in the Vibrio, the Filaria, the Gordius, the Nais, and throughout the whole series of articulated animals. The contrast between the receiving and the discharging organs, which are placed at the two ends of the body, controls the whole organization. The mouth and the anus are

[1] From this statement it is plain that Baer has a very definite idea of the plan of structure, and that he has reached it by a very different road from that of Cuvier. It is clear, also, that he understands the distinction between a plan and its execution. But his ideas respecting the different features of structure are not quite so precise. He does not distinguish, for instance, between the complication of structure as determining the relative rank of the orders, and the different ways in which, and the different means with which the plans are executed, as characteristic of the classes.

[2] Without translating verbatim the descriptions Baer gives of his types, which are greatly abridged here, they are reproduced as nearly as possible in his own words.

always at opposite ends, and usually also the sexual organs, though their opening is sometimes farther forward; this occurs, however, more frequently in the females, in which these organs have a double function, than in the males. When both sexual organs are removed from the posterior extremity, the opening in the female usually lies farther forward than in the male. So is it in the Myriapods and the Crabs. The Leeches and Earthworms present a rare exception. The receptive pole being thus definitely fixed, the organs of senses, as instrumental to the receptivity of the nervous system, early reach an important degree of perfection. The intestinal canal, as well as the vascular stems and the nervous system, extend through the whole length of the body, and all organic motion in these animals has the same prevailing direction. Only subordinate branches of these organs arise laterally, and chiefly wherever the general contrast, manifested in the whole length is repeated in such a manner that, for each separate segment, the same contrast arises anew, in connection with the essential elements of the whole organism. Hence the tendency in these animals to divide into many segments in the direction of the longitudinal axis of the body. In the true Insects, undergoing metamorphosis, these segments unite again into three principal regions, in the first of which the life of the nerves prevails; in the second, motion; in the third, digestion; though neither of the three regions is wholly deprived of any one of these functions. Besides the opposition between before and behind, a less marked contrast is observed in a higher stage of development between above and below. A difference between right and left forms a rare exception, and is generally wanting. Sensibility and irritability are particularly developed in this series. Motion is active, and directed more decidedly forward, in proportion as the longitudinal axis prevails. When the body is contracted as in spiders and crabs, its direction is less decided. The plastic organs are little developed; glands, especially, are rare, and mostly replaced by simple tubes.

III. *The Massive Type.* We may thus call the type of Mollusks, for neither length nor surface prevails in them, but the whole body and its separate parts are formed rather in round masses which may be either hollow or solid. As the chief contrast of their structure is not between the opposite ends of the body, nor between the centre and periphery, there is almost throughout this type an absence of symmetry. Generally the discharging pole is to the right of the receptive one. The discharging pole, however, is either near the receptive one, or removed from it, and approximated to the posterior extremity of the body. As the tract of the digestive apparatus is always determined by these two poles, it is more or less arched; in its simplest form it is only a single arch, as in Plumatella. When that canal is long, it is curled up in a spiral in the centre, and the spiral probably has its definite laws. For instance, the anterior part of the alimentary canal appears to be always placed under the posterior. The principal currents of blood are also in arches, which do not coincide with the medial line of the body. The nervous system consists of diffused ganglia, united by threads, the larger ones being around the œsophagus. The nervous system and the organs of sense appear late; the motions are slow and powerless.

IV. *The Vertebrate Type.* This is, as it were, composed of the preceding types, as we distinguish an animal and a vegetative system of the body, which, though influencing one another in their development, have singly a peculiar typical organization. In the animal system, the articulation reminds us of the second type, and the discharging and receiving organs are also placed at opposite ends. There is, however, a marked difference between the Articulates and the Vertebrates, for the animal system of the Vertebrates is not only doubled along the two sides, but at the same time upwards and downwards, in such a way that the two lateral walls which unite below circumscribe the vegetative system, while the two tending upward surround a central organ of the animal life, the brain and spinal marrow, which is wanting in Invertebrates. The solid frame represents this type most completely, as from its medial axis, the backbone, there arise upward arches which close in an upper crest, and downward arches which unite, more or less, in a lower crest. Corresponding to this we see four rows of nervous threads along the spinal marrow, which itself contains four strings, and a quadripartite grey mass. The muscles of the trunk form also four principal masses, which are particularly distinct in the Fishes. The animal system is therefore doubly symmetrical in its arrangement. It might easily be shown how the vegetative systems of the body correspond to the type of Mollusks, though influenced by the animal system.

From the illustrations accompanying this discussion of the great types or branches of the animal kingdom, and still more from the paper published by K. E. von Baer in the Nova Acta,[1] it is evident, that he perceived more clearly and earlier than any other naturalist, the true relations of the lowest animals to their respective branches. He includes neither Bryozoa nor Intestinal Worms among Radiata, as Cuvier, and after him so many modern writers, did, but correctly refers the former to the Mollusks and the latter to the Articulates.

Comparing these four types with the embryonic development, von Baer shows that there is only a general similarity between the lower animals and the embryonic stages of the higher ones, arising mainly from the absence of differentiation in the body, and not from a typical resemblance. The embryo does not pass from one type to the other; on the contrary, the type of each animal is defined from the

[1] Beiträge zur Kenntniss der niedern Thiere, Nova Acta Academiæ Naturæ Curiosorum, vol. 13, Part 2, 1827, containing seven papers, upon Aspidogaster, Distoma, and others, Cercaria, Nitzschia, Polystoma, Planaria, and the general affinities of all animals. These "Beiträge," and the papers in which Cuvier characterized for the first time the four great types of the animal kingdom, are among the most important contributions to general Zoölogy ever published.

beginning and controls the whole development. The embryo of the Vertebrate is a Vertebrate from the beginning, and does not exhibit at any time a correspondence with the Invertebrates. The embryos of Vertebrates do not pass in their development through other permanent types of animals. The fundamental type is first developed, afterwards more and more subordinate characters appear. From a more general type, the more special is manifested, and the more two forms of animals differ, the earlier must their development be traced back to discern an agreement between them. It is barely possible that in their first beginning all animals are alike and present only hollow spheres, but the individual development of the higher animals certainly does not pass through the permanent forms of lower ones. What is common in a higher group of animals is always sooner developed in their embryos than what is special; out of that which is most general arises that which is less general, until that which is most special appears. Each embryo of a given type of animals, instead of passing through other definite types, becomes on the contrary more and more unlike them. An embryo of a higher type is, therefore, never identical with another animal type, but only with an embryo.

Thus far do the statements of von Baer extend.[1] It is evident from this, that he has clearly perceived the limitation of the different modes of embryonic development within the respective branches of the animal kingdom, but it is equally certain that his assertions are too general to furnish a key for the comparison of the successive changes which the different types undergo within their respective limits, and that he is still vaguely under the impression, that the development corresponds in its individualization to the degrees of complication of structure.

[1] The account which Huxley gives of Baer's views, (see Baden Powell's Essays, Appendix 7, p. 495,) is incorrect. Baer did not "demonstrate that the classification of Cuvier was, in the main, simply the expression of the fact, that there are certain common *plans of development* in the animal kingdom," etc., for Cuvier recognized these plans in the *structure* of the animals, before Baer traced their development, and Baer himself protests against an identification of his views with those of Cuvier. (Baer's Entwick., p. 7.) Nor has Baer demonstrated the "doctrine of the unity of organization of all animals," and placed it "upon a footing as secure as the law of gravitation," and arrived at "the grandest law," that, up to a certain point, the development "*followed a plan common to all animals.*" On the contrary, Baer admits four distinct types of animals, and four modes of development. He only adds: "It is barely possible that in their first beginning all animals are alike." Huxley must also have overlooked Cuvier's introduction to the "Règne Animal," (2d edit., vol. 1, p. 48, quoted verbatim above, p. 193,) when he stated that Cuvier "did not attempt to discover upon what plans animals are constructed, but to ascertain in what manner the facts of animal organizations could be thrown into the fewest possible propositions." On the contrary, Cuvier's special object, for many years, has been to point out these plans, and to show that they are characterized by peculiar structures, while Baer's merit consists in having discovered four *modes of development*, which coincide with the branches of the animal kingdom, in which Cuvier recognized four different *plans of structure*. Huxley is equally mistaken when he says that Cuvier adopted the nervous system "as the base of his great divisions."

This could hardly be otherwise, as long as the different categories of the structure of animals had not been clearly distinguished.[1]

CLASSIFICATION OF K. E. VON BAER.

In conformity with his embryological investigations, K. E. von Baer proposes the following classification.

I. Peripheric Type. (RADIATA.) Evolutio radiata. The development proceeds from a centre, producing identical parts in a radiating order.

II. Massive Type. (MOLLUSCA.) Evolutio contorta. The development produces identical parts curved around a conical or other space.

III. Longitudinal Type. (ARTICULATA.) Evolutio gemina. The development produces identical parts arising on both sides of an axis and closing up along a line opposite the axis.

IV. Doubly Symmetrical Type. (VERTEBRATA.) Evolutio bigemina. The development produces identical parts arising on both sides of an axis, growing upwards and downwards, and shutting up along two lines, so that the inner layer of the germ is inclosed below and the upper layer above. The embryos of these animals have a dorsal cord, dorsal plates, and ventral plates, a nervous tube and branchial fissures.

- 1°. They acquire branchial fringes;
  - a. But no genuine lungs are developed.
    - α. The skeleton is not ossified. Cartilagineous Fishes.
    - β. The skeleton is ossified. Fishes proper.
  - b. Lungs are formed. Amphibia.
    - α. The branchial fringes remain. Sirens.
    - β. The branchial fringes disappear. Urodela and Anura.
- 2°. They acquire an allantois, but
  - a. Have no umbilical cord;
    - α. Nor wings and air sacs. Reptiles.
    - β. But wings and air sacs. Birds.
  - b. Have an umbilical cord. Mammalia.
    - α. Which disappears early;
      - 1°. Without connection with the mother. Monotremata.
      - 2°. After a short connection with the mother. Marsupialia.
    - β. Which is longer persistent;
      - 1°. The yolk sac continues to grow for a long time.
        - The allantois grows little. Rodentia.
        - The allantois grows moderately. Insectivora.
        - The allantois grows much. Carnivora.
      - 2°. The yolk sac increases slightly.
        - The allantois grows little. Umbilical cord very long. Monkeys and Man.
        - The allantois continues to grow for a long time. Placenta in simple masses. Ruminants.
        - The allantois continues to grow for a long time. Placenta spreading. Pachyderms and Cetacea.

[1] Compare Chap. II., Sect. 1 to 9.

CLASSIFICATION OF VAN BENEDEN.

Van Beneden has also proposed a classification based upon Embryology, which was first sketched in his paper upon the Embryology of Bryozoa: Recherches sur l'anatomie, la physiologie et l'embryogénie des Bryozoaires, Bruxelles, 1845, 4to., and afterwards extended in his Comparative Anatomy: Anatomie comparée, Bruxelles, (without date, but probably from the year 1855,) 1 vol. 12mo.

I. HYPOCOTYLEDONES or HYPOVITELLIANS. (Vertebrata.) The vitellus enters the body from the ventral side.
- CL. 1. Mammalia. (Primates, Cheiroptera, Insectivora, Rodentia, Carnivora, Edentata, Proboscidea, Ungulata, Sirenoidea, Cetacea.)
- CL. 2. Birds. (Psittaceæ, Rapaces, Passeres, Columbæ, Gallinæ, Struthiones, Grallæ, Palmipedes.)
- CL. 3. Reptiles. (Crocodili, Chelonii, Ophidii, Saurii, Pterodactyli, Simosauri, Plesiosauri, Ichthyosauri.)
- CL. 4. Batrachians. (Labyrinthodontes, Peromelia, Anura, Urodela, Lepidosirenia.)
- CL. 5. Fishes. (Plagiostomi, Ganoidei, Teleostei, Cyclostomi, Leptocardii.)

II. EPICOTYLEDONES or EPIVITELLIANS. (Articulata.) The vitellus enters the body from the dorsal side.
- CL. 6. Insects. (Coleoptera, Nevroptera, Strepsiptera, Hymenoptera, Lepidoptera, Diptera, Orthoptera, Hemiptera, Thysanura, Parasita.)
- CL. 7. Myriapodes. (Diplopoda, Chilopoda.)
- CL. 8. Arachnides. (Scorpiones, Araneæ, Acari, Tardigrada.)
- CL. 9. Crustacea. (Decapoda, Stomapoda, Amphipoda, Isopoda, Læmodipoda, Phyllopoda, Lophyropoda, Xiphosura, Siphonostoma, Myzostoma, and Cirripedia.)

III. ALLOCOTYLEDONES or ALLOVITELLIANS. (Mollusco-Radiaria.) The vitellus enters the body neither from the ventral nor from the dorsal side.
- CL. 10. Mollusca. Including Cephalopoda, Gasteropoda, Pœcilopoda, and Brachiopoda. (Acephala, Tunicata, and Bryozoa.)
- CL. 11. Worms. (Malacopoda, Annelides, Siponculides, Nemertini, Nematodes, Acanthocephali, Scoleides, Hirudinei.)
- CL. 12. Echinoderms. (Holothuriæ, Echinides, Stellerides, Crinoides, Trematodes, Cestodes, Rotiferi, Planariæ.)
- CL. 13. Polyps. Including Tunicata, Bryozoa, Anthozoa, Alcyonaria, and Medusæ, as orders. (Ctenophoræ, Siphonophoræ, Discophoræ, Hydroids, Anthophoridæ.)
- CL. 14. Rhizopods. Only the genera mentioned.
- CL. 15. Infusoria. Only genera and families mentioned.

Van Beneden thinks the classification of Linnæus truer to nature than either that of Cuvier or of de Blainville, as the class of Worms of the Swedish naturalist corresponds to his Allocotyledones, that of Insects to his Hypocotyledones, and the four classes of Pisces, Amphibia, Aves, and Mammalia to his Hypocotyledones. He compares his primary divisions to the Dicotyledones, Monocotyledones, and Acotyledones of the vegetable kingdom. But he overlooks that the Cephalopods are not Allocotyledones, and that any group of animals which unites Mollusks, Worms, and Radiates in one great mass cannot be founded upon correct principles. As to his classes, I can only say that if there are natural classes among animals, there never was a combination of animals proposed since Linnæus, less likely to answer to a philosophical idea of what a class may be, than that which unites Tunicata with Polyps and Acalephs. In his latest work, Van Beneden has introduced in this classification many important improvements and additions. Among the additions, the indication of the orders, which are introduced in brackets in the diagram above, deserve to be particularly noticed. These changes relate chiefly to the Mollusks and Polyps; the Tunicata and Bryozoa being removed from the Polyps to the Mollusks. The Acalephs and Polypi, however, are still considered as forming together one single class.

The comparison, instituted by Van Beneden between his classification of the animal kingdom and that of the plants most generally adopted now, leads me to call again attention to the necessity of carefully scrutinizing anew the vegetable kingdom, with the view of ascertaining how far the results I have arrived at concerning the value of the different kinds of natural groups existing among animals,[1] apply also to the plants. It would certainly be premature to assume, that because the branches of the animal kingdom are founded upon different plans of structure, the vegetable kingdom must necessarily be built also upon different plans. There are probably not so many different modes of development among plants as among animals; unless the reproduction by spores, by naked polyembryonic seeds, by angiospermous monocotyledonous seeds, and by angiospermous dicotylodonous seeds, connected with the structural differences exhibited by the Acotyledones, Gymnospermes, Monocotyledones, and Dicotyledones, be considered as amounting to an indication of different plans of structure. But even then these differences would not be so marked as those which distinguish the four branches of the animal kingdom. The limitation of classes and orders, which presents comparatively little difficulty in the animal kingdom, is least advanced among plants, whilst botanists have thus far been much more accurate than zoölogists in characterizing families. This is, no doubt, chiefly owing to the peculiarities of the two organic kingdoms.

It must be further remarked, that in the classification of Van Beneden the animals united under the name of Allocotyledones are built upon such entirely different plans of structure, that their combination should of itself satisfy any unprejudiced observer that any principle which unites them in that way cannot be true to nature.

[1] See Chap. II., p. 137 to 178.

DIAGRAM OF THE DEVELOPMENT OF ANIMALS BY KÖLLIKER.

KÖLLIKER, (A.,) in his Entwickelungsgeschichte der Cephalopoden, Zurich, 1844, 1 vol. 4to., p. 175, has submitted the following diagram of the development of the animal kingdom.

A. The embryo arises from a primitive part. (Evolutio ex una parte.)
- 1°. It grows in two directions, with bilateral symmetry. (Evolutio bigemina.)
  - *a.* The dorsal plates close up. **Vertebrata.**
  - *b.* The dorsal plates remain open and are transformed into limbs. **Articulata.**
- 2°. It grows uniformly in every direction. (Evolutio radiata.) And
  - *a.* Incloses the embryonal vesicle entirely.
    - *α.* This takes place very early. **Gasteropoda** and **Acephala.**
    - *β.* This takes place late. (Temporary vitelline sac.) **Limax.**
  - *b.* Contracts above the embryonal vesicle. (Genuine vitelline sac.) **Cephalopoda.**

A. The whole body of the embryo arises simultaneously. (Evolutio ex omnibus partibus.)
- 1°. It grows in the direction of its transverse axis,
  - *a.* With its hind body. **Radiata.** (Echinoderms.)
  - *b.* With the fore body, and
    - *α.* The hind body does not grow. **Acalephs.**
    - *β.* The hind body grows longitudinally. **Polypi.**
- 2°. It grows in the direction of its longitudinal axis. **Worms.**

I have already shown how unnatural a zoölogical system must be which is based upon a distinction between total or partial segmentation of the yolk.[1] No more can a diagram of the development of animals, which adopts this difference as fundamental, be true to nature, even though it is based upon real facts. We ought never to single out isolated features, by which animals may be united or separated, as most anatomists do; our aim should rather be to ascertain their general relations, as Cuvier and K. E. von Baer have so beautifully shown.[2] I think also, that the homology of the limbs of Articulata and the dorsal plates of Vertebrata is more than questionable. The distinction, introduced between Polyps and Acalephs and these and the other Radiates, is not any better founded. It seems also quite inappropriate to call the development of Mollusks, evolutio radiata, especially after Baer had designated, under that same name, the mode of formation of the branch of Radiates, for which it is far better adapted.

[1] Chap. III., Sect. 1, p. 171.

[2] The principles of classification advocated by Baer are so clearly expressed by him, that I cannot resist the temptation of quoting some passages from the paper already mentioned above, p. 224, especially now, when I feel called upon to oppose the views of one of his most distinguished colleagues. "Vor allen Dingen muss man, um eine richtige Einsicht in die gegenseitige Verwandtschaft der Thiere zu erlangen, **die verschiedenen Organisationstypen** von den **verschiedenen Stufen der Ausbildung** stets unterscheiden. Dass man diesen Unterschied gewöhnlich nicht im Auge behalten hat, scheint uns zu den sonderbarsten Zusammenstellungen geführt zu haben." Beiträge, etc., Acta Nova, vol. 13, p. 739.

CLASSIFICATION OF VOGT.

Contrast between the Embryo and the Yolk.

I. VERTEBRATA. Yolk ventral.

CL. 1. Mammalia. 1°. Aplacentaria; *Ord.* Monotremata, Marsupialia. 2°. Placentaria. *Ser.* 1. *Ord.* Cetacea, Pachydermata, Solidungula, Ruminantia, and Edentata; *S.* 2. Pinnipedia, Carnivora; *S.* 3. Insectivora, Volitantia, Glires, Quadrumana, Bimana.

CL. 2. Aves. *Ser.* 1. Insessores; *Ord.* Columbæ, Oscines, Clamatores, Scansores, Raptatores; *Ser.* 2. Autophagi; *Ord.* Natatores, Grallatores, Gallinacea, Cursores.

CL. 3. Reptilia. *Ord.* Ophidia, Sauria, Pterodactylia, Hydrosauria, and Chelonia.

CL. 4. Amphibia. *Ord.* Lepidota, Apoda, Caudata, Anura.

CL. 5. Pisces. *Ord.* Leptocardia, Cyclostomata, Selachia, Ganoidea, Teleostia.

II. ARTICULATA. Yolk dorsal.

CL. 6. Insecta. *Subcl.* 1. Ametabola; *Ord.* Aptera. *Subcl.* 2. Hemimetabola; *Ord.* Hemiptera and Orthoptera. *Subcl.* 3. Holometabola; *Ord.* Diptera, Lepidoptera, Strepsiptera, Nevroptera, Coleoptera, Hymenoptera.

CL. 7. Myriapoda. Only divided into families.

CL. 8. Arachnida. *Series* 1. Pycnogonida and Tardigrada; *Ord.* Acarina, Araneida. *Series* 2. With three families.

CL. 9. Crustacea. *Subcl.* 1. Entomostraca; *Ord.* Cirripedia, Parasita, Copepoda, Phyllopoda, Trilobita, Ostracoda. *Subcl.* 2. Xiphosura. *Subcl.* 3. Podophthalma; *Ord.* Stomapoda, Decapoda. *Subcl.* 4. Edriophthalma; *Ord.* Læmipoda, Amphipoda, Isopoda.

Transformation of the whole Yolk into the Embryo.

III. CEPHALOPODA. Yolk cephalic.

CL. 10. Cephalopoda. *Ord.* Tetrabranchiata and Dibranchiata.

IV. MOLLUSCA. Irregular disposition of organs.

CL. 11. Cephalophora. *Subcl.* 1. Pteropoda. *Subcl.* 2. Heteropoda. *Subcl.* 3. Gasteropoda; *Ord.* Branchiata and Pulmonata. — Chitonida.

CL. 12. Acephala. *Subcl.* 1. Brachiopoda; *Ord.* Rudista, Brachiopoda. *Subcl.* 2. Lamellibranchia; *Ord.* Pleurochoncha, Orthoconcha, Inclusa.

CL. 13. Tunicata. *Ord.* Ascidiæ, Biphora. } Molluscoidea.
CL. 14. Ctenophora. Only subdivided into families. } Molluscoidea.
CL. 15. Bryozoa. *Ord.* Stelmatopoda, Lophopoda. } Molluscoidea.

V. VERMES. Organs bilateral.

CL. 16. Annelida. *Ord.* Hirudinea, Gephyrea, Scoleina, Tubicola, Errantia.

CL. 17. Rotatoria. *Ord.* Sessilia, Natantia.

CL. 18. Platyelmia. 1°. *Ord.* Cestoidea, Trematoda. 2°. *Ord.* Planarida, Nemertina.

CL. 19. Nematelmia. *Ord.* Gregarinea, Acanthocephala, Gordiacei, Nematoidei.

VI. RADIATA. Organs radiate.

CL. 20. Echinodermata. *Ord.* Crinoidea, Stellerida, Echinida, Holothurida.

CL. 21. Siphonophora. Only subdivided into families.

CL. 22. Hydromedusæ. Not clearly subdivided into orders.

CL. 23. Polypi. *Ord.* Hexactinia, Pentactinia, Octactinia.

No Egg.

VII. PROTOZOA.

CL. 24. Infusoria. *Ord.* Astoma and Stomatoda.

CL. 25. Rhizopoda. *Ord.* Monosomatia and Polythalamia.

The classification of Vogt (Zoologische Briefe, q. a., p. 180) presents several new features, one of which is particularly objectionable. I mean the separation of the Cephalopoda from the other Mollusks, as a distinct primary division of the animal kingdom. Having adopted the fundamental distinction introduced by Kölliker between the animals in which the embryo is developed from the whole yolk, and those in which it arises from a distinct part of it, Vogt was no doubt led to this step in consequence of his interesting investigations upon Actæon, in which he found a relation of the embryo to the yolk differing greatly from that observed by Kölliker in Cephalopods. But as I have already shown above, this cannot any more justify their separation, as branches, than the total segmentation of the yolk of Mammalia could justify the separation of the latter from the other Vertebrates. Had the distinction made by Vogt, between Cephalopods and the other Mollusks, the value he assigns to it, Limax should also be separated from the other Gasteropoda. The assertion that Protozoa produce no eggs, deserves no special consideration after what has already been said in the preceding sections respecting the animals themselves. As to the transfer of the Ctenophora to the type of Mollusks, it can in no way be maintained.

Before closing this sketch of the systems of Zoölogy, I cannot forego the opportunity of adding one general remark. If we remember how completely independent the investigations of K. E. von Baer were from those of Cuvier, how different the point of view was from which they treated their subject, the one considering chiefly the mode of development of animals, while the other looked mainly to their structure; if we further consider how closely the general results at which they have arrived agree throughout, it is impossible not to be deeply impressed with confidence in the opinion they both advocate, that the animal kingdom exhibits four primary divisions, the representatives of which are organized upon four different plans of structure, and grow up according to four different modes of development. This confidence is further increased when we perceive that the new primary groups which have been proposed since are neither characterized by such different plans, nor developed according to such different modes of development, but exhibit simply minor differences. It is, indeed, a very unfortunate tendency, which prevails now almost universally among naturalists, with reference to all kinds of groups, of whatever value they may be, from the branches down to the species, to separate at once from one another any types which exhibit marked differences, without even inquiring first whether these differences are of a kind that justifies such separations. In our systems, the quantitative element of differentiation prevails too exclusively over the qualitative. If such distinctions are introduced under well-sounding names, they are almost certain to be adopted; as if science gained any thing by concealing a difficulty under a Latin or Greek name, or was advanced by the additional burden of a new nomenclature. Another objectionable practice, prevailing quite as extensively also, consists in the change of names, or the modification of the extent and meaning of old ones, without the addition of new information or of new views. If this practice is not abandoned, it will necessarily end in making Natural History a mere matter of nomenclature, instead of fostering its higher philosophical character. Nowhere is this abuse of a useless multiplication of names so keenly felt as in the nomenclature of the fruits of plants, which exhibits neither insight into vegetable morphology, nor even accurate observation of the material facts.

May we not return to the methods of such men as Cuvier and Baer, who were never ashamed of expressing their doubts in difficult cases, and were always ready to call the attention of other observers to questionable points, instead of covering up the deficiency of their information by high-sounding words!

In this rapid review of the history of Zoölogy, I have omitted several classifications, such as those of Kaup and Van der Hoeven, which might have afforded an opportunity for other remarks, but I have already extended this digression far enough to show how the standards I have proposed in my second chapter may assist us in testing the value of the different kinds of groups generally adopted in our classifications, and this was from the beginning my principal object in this inquiry. The next step should now be to apply these standards also to the minor divisions of the animal kingdom, down to the genera and species, and to do this for every class singly, with special reference to the works of monographers. But this is such an herculean task, that it can only be accomplished by the combined efforts of all naturalists, during many years to come.

THIS PAGE BLANK

PART II.

NORTH AMERICAN TESTUDINATA.

NORTH AMERICAN TESTUDINATA.

CHAPTER FIRST.

THE ORDER OF TESTUDINATA; ITS RANK, CLASSIFICATION, AND GENERAL CHARACTERS.

SECTION I.

RANK OF THE TESTUDINATA.

The necessity of reviewing critically the North American Testudinata,[1] in order to obtain a well-founded standard of comparison between the successive changes in the development of those species whose embryology I have examined, and the full-grown representatives of the types inhabiting the continent of North America, affords me a welcome opportunity of testing the principles of classification discussed in the first part of this work. It will be seen from this examination that, though their systematic arrangement requires here and there considerable modifications, yet the progress of science during this century has been such, that the changes I propose to introduce in the most generally adopted classification of the Testudinata are sometimes only confirmations of modifications already hinted at by previous writers, whose opinions have not been sustained from want of satisfactory

[1] The name Testudinata being older than that of Chelonians, and yet entirely synonymous with it, I deem it necessary to retain it in future as the systematic name of this order. The name Chelonians is, however, so generally adopted, that it may not be desirable to discard it altogether from our illustrations. I shall therefore still use it whenever this group is contrasted with the Saurians and Ophidians, as they were named together, according to the same principle.

evidence, though they were undoubtedly led to their results by that instinctive appreciation of the true relations among organized beings, which, in the history of science, is so often found to precede the practical demonstration and establishment of final results. Certainly, it is an unquestionable fact, that correct views are frequently propounded upon subjects of natural science, the proof of which, in the first imperfect state of our knowledge, is still wanting. In the case before us, we shall see how the practice of naturalists has generally led them to results which have not been, till now, susceptible of demonstration; but I hold that the possibility of thus accounting in the end for views instinctively adopted, and so often generally accepted, is in itself satisfactory evidence that the principles which furnish the final demonstration are true to nature.

It might seem superfluous here to show that the class of Reptiles belongs to the type of Vertebrates, did it not afford an opportunity of showing that the definition of the great branches of the animal kingdom given above is correct. It has been stated[1] that these primary divisions did not rest upon peculiar structures, upon a distinct combination of given systems of organs, but exclusively upon a plan of structure. To show that Reptiles are Vertebrates, it may be sufficient, in practice, to exhibit their solid internal frame; but that this cannot be considered as the essential characteristic of a vertebrated animal is amply proved by the fact that Amphioxus no more has a skeleton, properly speaking, than the Myxinoids and Petromyzontes; yet no one doubts that their true position is among Vertebrates. Again, in Testudinata, the largest part of the skeleton is truly external, their bony box being only covered by comparatively thin scales or a naked skin. There is, indeed, no class in which a greater diversity of structure is exhibited than among Reptiles; for, without mentioning the Batrachians, which constitute a class by themselves, what extraordinary difference is there not between Snakes, Lizards, and Turtles! To show that notwithstanding this variety of structure, these animals actually belong to the branch of Vertebrata, is the object I have in view; and if it can be shown that so diversified a class belongs to that type, according to our understanding of the term branch, we shall have the required proof that our definition is true to nature. Now I have stated that branches are founded upon different plans of structure. What is, then, that plan in Vertebrates which unites Amphioxus, Cyclostomes, Sharks, Skates, Bony Fishes, Ichthyoids, Salamanders, Toads, Frogs, Snakes, Lizards, Crocodiles, Turtles, Birds, Whales, Marsupials, our common Quadrupeds, Bats, Monkeys, and Man, which includes them all in one and the same group, and shows that group to be natural?

The body of all Vertebrates represents a double tube, one above the other, separated by a longitudinal axis, and varying in amplitude and in form at dif-

[1] See Part I., Chap. 2, Sect. 1, p. 141–144.

ferent points of their longitudinal diameter. These tubes are surrounded by walls, varying in thickness, as the spaces they inclose vary in size, the upper one containing the centrès of the nervous system, the lower one the organs through which life is maintained; while the walls, in connection with the intervening longitudinal axis, constitute a locomotive apparatus, and serve also to sustain the relations with the surrounding media.

These characteristics of the type of Vertebrates do not necessarily imply a definite structure; they apply as well to the imperfectly organized Amphioxus as to Man, for they do not involve the idea of a distinct head, nor that of locomotive appendages arranged in pairs, nor that of a branchial or pulmonary system of respiration, nor that of a heart as the centre of circulation, nor indeed any of those anatomical and histological differences or peculiarities which are constantly and, in my opinion, erroneously introduced in the characteristics of the great types of the animal kingdom. The external development of the skeleton of the Turtle no longer seems an anomaly, when we remember that it forms a part of those walls which surround the spinal cavity on the one hand, and the abdominal cavity on the other.

If we next consider the Reptiles as a class, we must remember that ever since Linnæus these animals have been considered as one class. Cuvier, and with him all herpetologists, have agreed in considering them all as one class. We find de Blainville, for the first time, insisting upon the separation of the Batrachians from the other Reptiles as a distinct class. This view has also been adopted by Milne-Edwards, while Wagler has separated a few of their extinct types, the Ichthyosauri, the Plesiosauri, and the Pterodactyli, to unite them with the Ornithorhynchus and Echidna as one class, under the name of Gryphi. The incongruity of this combination is so obvious, now that these fossil animals have been described in such a masterly manner by R. Owen, that I will not dwell upon its artificial character here. But the separation of the Batrachians from the other Reptiles as a class deserves a special notice, and if the definition I have given above of a class, as such, is correct, the result cannot be doubtful. I have stated that a class was defined by the manner in which the plan of structure of the branch to which it belongs is carried out. I have condensed that definition by saying, that the limitation of a class is a question of ways and means. Now, before applying this definition to the question of the separation of Batrachians from other Reptiles, I would make two remarks: In the first place, that this definition was not made to suit the case, but was arrived at by a critical consideration of the foundation upon which those classes rest, about whose natural limits there have never existed great doubts among naturalists, such as the class of Mammalia, that of Birds, that of Cephalopods, that of Gasteropods, that of Insects, that of Crustacea, and that of Echinoderms; in the second place, that it is entirely erroneous to consider, as is universally done, that the classes exhibit modifications of the plan of structure of their respective branches.

It is no more true that Fishes, Reptiles, Birds, and Mammalia exhibit respectively modifications of the plan of structure of Vertebrates, than that Insects, or Crustacea, or Worms are respectively modifications of the type of Articulates, or the different classes of Mollusks and Radiates, modifications of their respective types. A Fish is as truly a Vertebrate as any Bird or Mammal; the plan is not at all modified; it is only executed in different ways and with different means. The plan which characterizes Vertebrates is no more modified in the Fish than in the Reptile; the plan of Articulates is no more modified in Insects than in Crustacea or Worms; the plan of Mollusks, as a plan, is the same in Cephalopods as in Gasteropods and Acephala; that of Radiates, the same in Polyps as in Acalephs and Echinoderms. What, then, constitutes the difference of each class in the same branch? It is the manner in which the plan of the branch to which they respectively belong is carried out. They are respectively characterized by the way in which, and the means with which, they are built up. The idea of radiation which is inherent in the plan of structure of Radiates is the same in all Radiates, in Polyps as well as in Medusæ and Echinoderms; but in the Polyps it is expressed in one way, in the Acalephs in another, and in Echinoderms in still another. This is equally true of all the other classes, with reference to the plan of their respective branches. The different ways in which, and the different means with which each plan is executed in its respective classes, go far to show that the branches themselves are founded in nature, for the means employed in carrying out these different plans in a variety of ways, in their different classes, are everywhere homological, and homological only within the limits of the same branch. We can trace no true homology between the systems of organs in Vertebrates and those in Articulates, nor between these and those of Mollusks; and a critical examination shows that the structure of Radiates is not homological with that of Mollusks.

Truly homological systems of organs, then, more or less complicated, constitute class characters; but, again, these homologies are only general as far as the branch is concerned, while within each class special homologies only can be traced. Had these distinctions been made before, what an amount of confused discussion might have been spared respecting homologies in the animal kingdom! I trust this statement, the correctness of which may easily be tested by a comparison of the Batrachians and the true Reptiles, will put an end to the useless and puerile attempts to homologize every point of ossification in any class of the Vertebrates with some part or other of the skeleton of all the other members of that type. I hope also it may prevent such fanciful investigations from being extended into the study of the other systems of organs.

Now, to return to the question of the natural limitation of Reptiles, it must be obvious that if classes differ by the manner in which the plan of their branch is carried out, or by the ways and means employed in framing their structure, we cannot suppose that animals which, like Batrachians, lay a large number of small eggs, the yolk of which is segmented in the well-known manner, to produce an embryo, without amnios and allantois, undergoing extensive metamorphosis after it is hatched, furnished with external gills, which actually perform respiratory functions, even though they may disappear at a later period of life, the skin of which is naked, etc.,[1] belong to the same class as the true Reptiles, the skin of which is covered with horny scales, which lay few, and comparatively large eggs surrounded with a shell, the yolk of which undergoes only a superficial segmentation, and from which is formed an embryo inclosed in an amnios, and afterwards in an allantois, and which, after being hatched, undergoes no marked transformation, etc. The conclusion that Batrachians and Reptiles constitute two distinct classes, the first of which is indeed more closely allied to Fishes than to the true Reptiles, is not only of great zoölogical importance, but has also the most direct bearing upon the question of the order of succession of Vertebrates in geological times, and cannot fail to give a new interest to our investigations upon this subject, as well as to increase the precision of our knowledge respecting the first appearance of Reptiles upon earth.

It will indeed be obvious at once, that if all the so-called Reptiles which have been mentioned as occurring in the carboniferous beds and even in strata below the coal, belong to the class of Batrachians and not to that of genuine Reptiles, the inference to be drawn from the presence of such animals during these ancient geological periods cannot be the same, and instead of leading to the assumption that conditions of existence similar to those which sustain our Reptiles prevailed as far back as these remains are found, we shall only have the evidence that the conditions essential to the life of Batrachians, but not to that of true Reptiles, were established then.

After this separation of the Batrachians from the true Reptiles, we have only three orders left in the class of Reptiles proper: the Ophidians, the Saurians, and the Chelonians. It would lead me too far from my immediate subject, were I to examine here, whether this is the most natural subdivision of Reptiles into orders. I shall limit myself, therefore, to the consideration of the Chelonians alone, remarking only, that whether this division be natural or not, whether we include the Crocodilians in the same order as the true Lizards, or whether we regard them with their fossil representatives as a distinct order, or whether we consider the

[1] See further details in any anatomical text-book.

Ichthyosauri, the Plesiosauri, the Pterodactyli, the Dinosauri, etc., as constituting several additional orders, these groups, as zoölogical divisions, have in themselves the character of orders, that is to say, they exhibit, when compared with one another, various degrees of complication of their structure, and stand, with reference to one another, higher or lower. It cannot be doubted, for instance, that compared with Lizards, the Snakes are an inferior group, and that the Chelonians, in which the different regions of the body are so distinctly marked and in which the head for the first time acquires a greater movability upon the neck, stand above the others, approaching indeed, in many respects, the class of Birds, especially the lower families of aquatic Birds, both in their form and in their mode of existence.

Now, this gradation, acknowledged by all, inasmuch as all herpetologists place the Chelonians at the head of this class and next to them the Saurians, while the Ophidians occupy a lower position, will serve as an illustration of my definition of orders as natural groups, characterized by the different degrees of complication of the special structure of their class, which complications determine their relative rank or standing. I would not, however, in this connection forget that some naturalists, Strauss[1] among others, have of late considered the Chelonians as a distinct class, and not as an order among Reptiles. Now, let us apply the test of our rules to this suggestion, remembering here again that these rules have been drawn from those classes of the animal kingdom, such as the Echinoderms, Acalephs, and Polyps, in which the orders are still more distinctly marked out in nature than in the one now under consideration.

To constitute a class apart from Ophidians and Saurians, the structure of Chelonians ought to be built up in a different way and with different means from that of Saurians and Ophidians. And now, is this the case? The Chelonians, like Saurians and Ophidians, undergo a development so identical, that we need only compare the investigations of Rathke upon that subject with those contained in this volume, to settle any doubts on that point. And as to structure, what difference is there, except differences in complication of structure, between Ophidians, Saurians, and Chelonians, both in their nervous systems and organs of senses, in their locomotive apparatus and in their intestines? Is not even the skeleton truly homological in all of them?[2] We cannot fail, therefore, to consider the view as fully sustained, that Chelonians represent an order, and nothing but an order, in the class of true Reptiles.

[1] STRAUSS-DURKHEIM, (H.,) Théologie de la Nature, Paris, 1852, 3 vols. 8vo.; vol. 1, p. 99 and 398.

[2] For further evidence that the structure of the Chelonians is truly homological with that of Saurians and Ophidians, and that the position of their limbs and the frame of their shield does not place them in an exceptional position, with reference to the other Reptiles, see below, Sect. 6 of this chapter.

SECTION II.

SPECIAL CLASSIFICATION OF TESTUDINATA.

Whatever be the name admitted to designate this remarkable group of the animal kingdom, and whatever be the rank or dignity assigned to it, whether simply considered as a genus, or a family, or an order, all naturalists, with the exception of Strauss,[1] agree in regarding the Turtles as a natural division in the class of Reptiles. They differ only with respect to its standing in the class, the extremes of opinion being between Linnæus, who admits it only as a genus, and Strauss-Dürkheim, who considers it as a distinct class. We have already seen that the correct view is that which considers it as an order.[2]

It is more difficult to determine the value of the minor groups into which the Testudinata have been subdivided. Without entering into more details upon the subject than are found in most works on Herpetology, we shall hardly be able to form a just estimate of the real value of all these divisions, especially as few authors agree upon this point with one another. Linnæus, for instance, unites all the Turtles he knew in one genus, including the marine as well as the fresh-water and land species. Brongniart,[3] for the first time, considers them as a distinct order, under the name "CHELONIENS," and divides them into three genera: Testudo, Emys, and Chelonia. Cuvier, a few years later in his "Règne Animal," enumerates five genera in that order, but without any further divisions. Oppel,[4] as early as 1811, before enumerating the genera, introduces two higher divisions, under the names of Chelonii and Amydæ for those Turtles which have oar-like or paddle feet, and those in which the fingers are distinguishable. These divisions of Oppel correspond to the sections Pinnata and Digitata of Merrem and Bell.[5] Gray,[6]

[1] Compare Part II., Chap. I., Sect. 1, p. 240.

[2] The various names applied by different authors to this order, are: TESTUDINATA, *Klein*, Quadrup. Disp. Lipsiæ, 1751; adopted by Oppel in 1811; by Merrem in 1820; by Fitzinger in 1826; by Bell in 1828; by Bonaparte in 1832; by LeConte in 1854. TESTUDINES, adopted by Wagler in 1830. CHELONII, proposed by Brongniart in 1800; adopted by Cuvier in 1817; by Gray in 1825; by Wiegmann in 1832; by Duméril and Bibron in 1835; by Bonaparte in 1836; by Holbrook in 1842. FORNICATA, proposed by Haworth in 1825. STERRICHROTES, proposed by Ritgen in 1828. TYLOPODA, proposed by F. Meyer in 1849.

[3] BRONGNIART, (AL.,) Essay d'une Classification naturelle des Reptiles, Paris, 1805, 4to.

[4] OPPEL, (M.,) Die Ordnungen, Familien und Gattungen der Reptilien, München, 1811, 1 vol., 8vo.

[5] MERREM, (B.,) Tentamen Systematis Amphibiorum, Marburg, 1820, 1 vol., 8vo. — BELL, (TH.,) Characters of the Order, Families, and Genera of Testudinata, Zoöl. Journal, 1828.

[6] GRAY, (J. E.,) A Synopsis of the Genera of Reptiles and Amphibia, Annals of Philosophy, 1825.

without acknowledging these higher divisions, admits five families: Cheloniadæ, Sphargidæ, Trionicidæ, Emydidæ, and Testudinidæ, as does also Bell, though this author divides these families between the two sections first introduced by Oppel, admitting however, for them, the names proposed by Merrem.

Fitzinger[1] has also five families in the order of Chelonians, but these do not exactly agree with those of Gray and Bell, for he unites the Sphargidæ and the Chelonidæ, but he adds another family under the name of Chelydoidea. Ritgen[2] admits, above the genera, three primary sections, Eretmochelones, Phyllopodochelones, and Podochelones; and so does also Wagler,[3] though he changes the names of Ritgen into Oiacopodes, Steganopodes, and Tylopodes, calling them tribes, while the whole order is considered as including a single family. F. Meyer[4] admits the same three subdivisions of his Tylopoda, (Testudinata,) but he gives them again new names. Wiegmann[5] divides the Testudinata into five families, without higher groups, namely, Chelonæ, Chersinæ, Emydæ, Chelydæ, Chilotæ. Swainson[6] admits also five families, but with still different limits. Prince Canino,[7] on the contrary, admits three families and four sub-families, but his three families do not correspond to the three sections or tribes of Wagler, as he unites the land and fresh-water Turtles into one family, while he considers the Trionychidæ as a distinct family, which both Ritgen and Wagler place with the common fresh-water Turtles. The land and fresh-water Turtles are to Canino only sub-families. Duméril and Bibron admit four families, Thalassites, Potamides, Elodites, and Chersites, and two sub-families.[8]

These apparently most discrepant classifications, if we judge them merely by the different names employed by their authors, have in themselves more similarity than would at first appear. For instance, the three genera of Brongniart correspond to the three sections or tribes of Ritgen and of Wagler; the three fami-

Notice that though Gray admits five families in 1831 as in 1825, he limits them differently in the second than in the first Synopsis.

[1] FITZINGER, (L. J.,) Neue Classification der Reptilien, Wien, 1826, 1 vol., 4to.; see also his Systema Reptilium, Vindobonæ, 1843, 1 vol., 8vo.

[2] RITGEN, (F. A.,) Versuch einer natürlichen Eintheilung der Amphibien, Nova Acta Nat. Cur., 1828, vol. 14.

[3] WAGLER, (J.,) Natürliches System der Amphibien, etc., München und Stuttgart, 1830, 1 vol. 8vo. Atlas folio.

[4] MEYER, (FR. I. C.,) System des Thierreichs, etc., Verhandl. Nat. Ver. Rheinl., 1849.

[5] WIEGMANN, (A. F. A.,) und RUTHE, (J.,) Handbuch der Zoologie, Berlin, 1832, 1 vol., 8vo. The Reptiles are by Wiegmann.

[6] SWAINSON, (W.,) Natural History and Classification of Fishes, Amphibians, and Reptiles, London. 1838–39, 2 vols., 12mo. These volumes form part of Dr. Lardner's Cabinet Cyclopedia.

[7] BONAPARTE, (C. LUCIAN, PRINCE OF CANINO,) Saggio di una distribuzione metodica degli Animali Vertebrati, Roma, 1832, 8vo.; see also his Cheloniorum Tabula analytica, Romæ, 1836.

[8] DUMÉRIL, (A. M. C.,) et BIBRON, (G.,) Erpétologie générale, ou Histoire naturelle complète des Reptiles, Paris, 1836, et seq., vol. 1.

lies, with two sub-families of Canino, correspond exactly to the four families of Duméril and Bibron, the difference lying only in the separation, as families, of the Chersites and Elodites by Duméril and Bibron, while they constitute two sub-families of the Testudinidæ of Canino. Again, the Chersites, the united Potamides and Elodites of Duméril and Bibron and their Thalassites represent the divisions of Ritgen and Wagler. I do not mean by this to say, that the separation of the Potamides and Elodites is not natural, but only to allude to the fact that Duméril and Bibron's Thalassites correspond exactly to Ritgen's Eretmochelones and to Wagler's Oiacopodes, while their Chersites answer to Ritgen's Podochelones and to Wagler's Tylopodes, the Potamides and Elodites of the French herpetologists corresponding together to the Phyllopodochelones and Steganopodes of the two German writers.

The agreement, and the discrepancies between these different systems, then, consist in this, that Oppel and Merrem and with them Bell, admit two higher subdivisions in the order of Testudinata, those with oar-like feet and those with distinct fingers, while Ritgen and Wagler admit three, distinguishing between those the visible fingers of which are webbed, and those in which they are entirely separated, while Duméril and Bibron introduce a farther distinction between those with webbed feet and a scaly body and those with a naked carapace, the Emyds proper and the Trionyx. Canino maintains this distinction between the naked and scaly fresh-water Turtles, but as he unites all the scaly ones together, whether their fingers are webbed or not, his division includes the Chersites of Duméril and Bibron as well as their Elodites. The sub-families which Duméril and Bibron introduce among the Elodites are founded upon the mode of motion of the neck, which exhibits differences already noticed by Wagler in 1830. Bell, Gray, and Fitzinger, who have a still larger number of groups which they call families, have founded them upon the same features which have led Duméril and Bibron to subdivide the Elodites. I do not here speak of the classifications of Fleming[1] and Latreille,[2] which are too artificial to deserve special notice.

Beyond these divisions, all authors mention only genera and sub-genera. Now, it must be obvious, from the agreement of all these writers in some points of their subdivisions of the Testudinata, that this order is not so homogeneous as to exclude higher divisions than genera in its classification. The point on which all agree is, the separation of the Turtles with oar-like, natatory organs of locomo-

[1] FLEMING, (J.) The Philosophy of Zoölogy, London, 1822, 2 vols., 8vo., divides the CHELONEA, as he calls the Testudinata, into those with a movable and those with an immovable sternum.

[2] LATREILLE, (P. A.,) Familles naturelles du règne animal, Paris, 1825, 1 vol., 8vo., divides the CHELONIANS into those which can retract their legs, Cryptopodes, and those which cannot, Gymnopodes.

tion from the rest of the order, in the farther subdivision of which we find, however, the greatest discrepancy among modern herpetologists. But, whether we subdivide the digitated Chelonians of Oppel and Merrem into two, or three, or more natural groups, the question at once arises, how these groups shall be called, whether they are sections, sub-orders, families, or tribes, names which in the chaos now prevailing in nomenclature might seem equally applicable to all and any of them, or whether nature points out a real difference between them. Let us consider, in the first place, the more extensive of these groups, such as they are admitted by Oppel under the names of CHELONII and AMYDÆ, and by Merrem and Bell under the names of PINNATA and DIGITATA. What do they indicate? A difference in the mode of locomotion, that is to say, a structural difference, and that difference is of such a kind that, whether consciously or unconsciously, all authors have regarded those Turtles which have pinnate limbs as inferior to those in which the fingers are distinct. We find, at least, that in all works in which the animal kingdom is arranged in a descending order, the digitated Testudinata are mentioned first, the pinnate last, and where these are subdivided, as they have been by Ritgen, Wagler, Duméril and Bibron, and Canino, those with club feet are placed above those with webbed fingers. Their intention is therefore evident, to mark the respective rank of the Testudinata in these subdivisions of the order, a gradation which is, however, not founded upon differences in the whole structure, but only on such as are prominently marked in some parts of the body. In as far then as this is correct, these divisions all partake of the character of orders; they are akin to what we have called orders, inasmuch as orders are founded upon the gradation or complication of structure, but they are not real orders, inasmuch as that gradation does not extend to all the organic systems of their structure. At least, it is neither so extensive as to afford a means of comparison of any of them singly with any other order of the class, without involving the enumeration of characters common to all; nor is the element of form, which is so important in the characteristics of families, introduced distinctly in any of these minor groups.

We can, therefore, consider these divisions only as sub-orders; and the precision with which their gradation can be pointed out from the Thalassites through the Potamides and Elodites to the Chersites leaves no doubt in my mind that, whether two general groups are to be adopted under the head of Testudinata, as Oppel, Merrem, and Bell recognize, or three, as Ritgen and Wagler admit, or three combined in the manner in which Canino has them, or four, as Duméril and Bibron have them, these divisions must be considered as sub-orders, since they express a gradation within the order, or, in other words, are founded, under certain limitations, upon characters of the same kind as those on which the whole order is founded, though these characteristics are confined to certain parts, instead of extending to the whole organization.

The next question which we have to consider here is, whether these sub-orders exhaust the natural subdivisions existing between the order and the genera; or, in other words, whether in this class the orders coincide with the families or not, for we have not yet examined the question whether every order has necessarily more than one family or not. My remarks in the third chapter of the first part of this work can leave no doubt that each of the four branches of the animal kingdom contains several classes, for we have seen that every one of them displays the plan of structure on which it is founded, as carried out in different ways and with different means. But we have seen from a supposed case, that if such a class included only a few species, or even several genera, or perhaps one or more families, there might be no foundation for a distinction of orders, if all these species, genera, and families presented only such a diversity of ultimate structure and such modifications of form as would not distinctly indicate among them a difference of rank, an appreciable gradation.[1] But where a class contains groups in which such differences as mark gradation and rank are clearly perceptible, then we have distinct orders, even should these orders coincide with the limits of the families, that is to say, be combined with such modifications of form that, though expressing a gradation, these groups would correspond with the characters upon which families are to be founded. Now it remains for us to examine whether this is the case among Testudinata; and since the Chelonii constitute so natural a sub-order, when contrasted with the Trionychidæ, the Emydoidæ, and the Testudinina, we may select it as a test of the existence of sub-orders in nature, and we shall afterwards extend our remarks to the other minor groups with the view of ascertaining how many divisions of this kind there truly are in the order of Testudinata.

Ever since naturalists have attempted to subdivide the Testudinata, those with pinnate limbs have been considered as a natural group, raised by most to the dignity of a family, and embracing, in all modern classifications at least, two genera, Chelonia and Sphargis, though some authors subdivide farther Chelonia into several genera, and even go so far as to consider Sphargis and Chelonia proper as the types of distinct families. Now, whether that group contains one or two families, it unquestionably exhibits very great uniformity of structure as a group, when compared to the other Testudinata. In the first place, the dermal ossification remains imperfect; next, the limbs preserve through life a character which is uniform in Testudinata, as long as their development is not complete, that is to say,

[1] See Part I., Chap. 1, Sect. 1, p. 5-7.

they retain undivided fingers, such as the embryos have, even exaggerating this feature, in the adult, into an elongated paddle for the anterior limbs. Chelonii constitute, then, the lowest sub-order in the order of Testudinata; and it will presently be seen that its characters are not derived from the form of its representatives. Those who are sufficiently conversant with the subject will be aware that when characters derived from the form have been added to the other characters in order to distinguish the Chelonii, they have answered but indifferently; indeed, the form of Sphargis and that of Chelonia differ much more than that of Emydoidæ compared with Testudinina. The scaly Chelonii, the Chelonioidæ proper, have their shield more or less heart-shaped, and the posterior angle is not prolonged into a projecting point extending far over the tail, as is the case among the naked Chelonii, the Sphargididæ. For this and other reasons which it would be superfluous to mention here, as my object is not now to characterize every group of Testudinata minutely, I hold that Chelonioidæ proper and Sphargididæ, which differ by their form, are two distinct families in the sub-order of Chelonii, and that this sub-order exhibits structural features of inferiority when contrasted with the other Testudinata. Gray and Bell, in their early publications, had, in my opinion, correctly distinguished Sphargidæ and Chelonidæ[1] as families, even though they afterwards gave up that distinction and placed them incorrectly upon one level with Trionyx, Emys, and Testudo. In this respect, Fitzinger presented this matter in a more correct light when, like Oppel, he contrasted the united Chelonii with the other groups of the order; but I believe he was mistaken in urging the reunion of the families of Sphargidæ and Chelonidæ. If the view which I have presented of the case is correct, the marine Turtles would constitute a sub-order, for which a variety of names had been proposed: that of Pterodactyli by Fr. Meyer, that of Thalassites by Duméril and Bibron, that of Oiacopodes by Wagler, that of Eretmochelones by Ritgen, that of Pinnata by Merrem, and that of Chelonii by Oppel, all of which are perfectly synonymous. That of Oppel, which is the oldest, having been proposed in 1811, should have made all the others superfluous, and ought now to be retained. This sub-order includes two families, the Chelonioidæ and the Sphargididæ, as these differ in form. Their characteristics are fully illustrated in the next chapter.

The scarcity of Trionyx in European museums seems to have prevented so accurate a study of that group as of the others. It is, at least, surprising that some of the ablest herpetologists have failed to perceive how greatly they differ from the other fresh-water Turtles. Wagler unhesitatingly unites them with the Emyds, while quite recently Major LeConte has united them with Chelydra.[2] Yet, as

[1] When I quote the systematic names of original writers, I follow their spelling; in other cases, I adopt that which seems to me correct.

[2] LECONTE, (MAJOR,) Catalogue of the North American Testudinata, in Proc. Ac. Nat. Sc., Phila. vii., 1854.

early as 1825, Gray had distinguished them as a family, which was adopted by Bell, by Fitzinger, by Canino, and by Duméril and Bibron, the latter only changing the name of Trionychidæ into that of Potamides. This group constitutes one of the most natural families among Turtles, at once recognized by the flat, thin shield of an elegant oval form, by the long neck, the pointed head, and projecting nose. But the question is farther, whether this family can be associated in one sub-order with Emys and Testudo, or not. If we consider the total absence of scales, the imperfect ossification of the shield, the absence of ossification of the margin, or the limited extent to which it is ossified, the slight protection of the jaw by a small, horny sheath, we cannot fail to recognize characters of inferiority in these features, when comparing them with those of the Emyds and Testudos; and I would not hesitate to consider that family, though exhibiting alone such characters, as forming a sub-order of the same organic value as that of the Chelonii, did we not observe similar differences between the Sphargididæ and the true Chelonioidæ, and had we not learned long ago that any amount of difference existing between two groups never constitutes a difference of kind. The question might even be raised, whether the very imperfect ossification of Aspidonectes, and especially the total absence of marginal scutes, do not place them below the Chelonioidæ. But when it is remembered that among Chelonii the ossification is still more imperfect, at least in Sphargis, and that the skin is as destitute of scales in this genus as in Trionyx, there can be little doubt left that all the peculiarities of Trionyx are only family characters. The structure of their limbs is almost as perfect as in Emys, and, as we shall see hereafter, their whole organization brings them close to the Emydoids, Chelys and Chelydra forming the intermediate links. The remaining two types, Emys and Testudo, evidently stand, in every respect, highest among the Amydæ or Digitata, and close the series of Testudinata.

I greatly question the propriety of separating Trionyx, Chelys, Emys, and Testudo as groups coequal with Chelonia, as so many herpetologists do. There are many modifications in the degree of separation of the fingers among them, which alone do not establish differences of the same kind nor of the same degree as between these on one side and Chelonia on the other, even though as to ossification, development of scales, and armature of jaws, Trionyx differs somewhat from Emys and Testudo, while the two latter agree as closely as possible with one another. I would, therefore, consider Testudo, Emys, Chelys, and Trionyx together as one sub-order, showing the whole number of sub-orders among Testudinata to be only two, CHELONII and AMYDÆ, — the latter, however, including a number of distinct families, as I shall demonstrate presently.

The same argument which has led us to consider Sphargis and Chelonia as distinct families, leads naturally to the separation of a number of families among this second sub-order, called Amydæ by Oppel. In the first place, we notice the Trionychidæ, so remarkable for the peculiarities already alluded to; next we have the North American Chelydroidæ with their fossil European representative; next the South American Chelyoidæ, the Hydraspididæ, the Cinosternoidæ, the Emydoidæ proper; and lastly, the Testudinina, each of which groups presents typical patterns of form which are constant within their limits, and strikingly contrasted when compared with one another. For it is not true, as is so frequently repeated, that the fresh-water Turtles are flat and broad when compared with the land Turtles. Some of our marsh Turtles, and especially our Ozotheca, are quite as high comparatively, and certainly as narrow as any of the land Turtles, whilst the Chelydroidæ with their carinated backs, their dentated margin, their broad, flat heads, their narrow, cross-like sternum, their large tail, their imperfectly retractile limbs and head, differ far more from the other Emydoidæ than any land Turtles. I do not, therefore, hesitate for a moment to consider these two groups as two distinct families. Of the family of Chelydroidæ, there are two species in the United States belonging to two distinct genera, as I have ascertained that Chelydra Serpentina differs generically from the Chel. Temminckii *Auct.*, for which I have proposed the name of *Gypochelys Temminckii.* Their thoroughly aquatic habits show them to be, next to Trionyx and Chelys, the lowest family among Amydæ. Next to them, I would place the family of Cinosternoids, on account of their less extensive sternum and of their more movable pelvis. There can be no doubt that they constitute a family by themselves, when in addition to the difference of form already alluded to it is found that they have no odd bone in the sternum, so that their lower shield divides into symmetrical halves, along an uninterrupted straight suture, following the middle line. The long-necked Hydraspids with retractile head, or rather whose head can be bent laterally and so protected under the shield, come next in order; but as they are all foreign to the United States, and I have had few opportunities for their study, I must omit any further mention of them. I would only recall, in this connection, the interesting fact that the types of land and fresh-water Turtles are so localized upon the surface of the globe, that, though the number of Testudinata is very great in the United States, not a single Hydraspid, for instance, is found within their limits, and only two Testudos occur in their southern parts, while the family of Chelydroids, on the contrary, belongs almost exclusively here, and is only found again in China. The true home of the genuine Emydoids is also North America, as the true home of the Chelyoids and Hydraspids is South America, though a few species of the latter family occur also in other parts of the world.

As a family, the Emydoidæ are easily characterized by their ovate form, swelling centrally, while the margin has a tendency to spread outward, in which last feature they agree with the Chelydroids and Hydraspids, while, in that respect, they differ strikingly from the Cinosternoids, the margin of which has a tendency to round itself up and turn inwards, as is also the case in the genuine Testudos, which constitute the last and highest family of the whole order. We shall presently see that among our native Emydoids there are two species which have generally been referred to the same genus, the Cistudo carolina and the C. Blandingii, one of which, however, is a genuine fresh-water species of the genus Emys, while the other is entirely terrestrial.

The family of Testudinina has always been circumscribed within its natural limits, ever since it was first distinguished.

Before we proceed to an analysis of the genera of the North American Testudinata, we may now recapitulate the results at which we have arrived respecting the general classification of the whole order, as follows:—

Order, Testudinata, *Klein*.

1st *Sub-order*, Chelonii, *Opp*. With two families, Chelonioidæ and Sphargididæ.

2d *Sub-order*, Amydæ, *Opp*. With seven families, Trionychidæ, Chelyoidæ, Hydraspididæ, Chelydroidæ, Cinosternoidæ, Emydoidæ, and Testudinina.

It should further be remarked that, as in all larger divisions of the animal kingdom, these families are not equally related to one another. The affinity of the Trionychidæ to the other families is not so close as that which brings the Cinosternoids near the Chelydroids, or certain Emydoids near the Testudinina, or the Hydraspids near the Chelyoids; yet after testing all their characters as far as my opportunities permitted, I have come to the conclusion that the seven groups above enumerated as families under the head of the sub-order Amydæ are truly natural families, characterized by different typical forms, which are defined by structural peculiarities, as we shall see more fully hereafter. The inequality among these families, in the degree of their relationship, is a feature which will appear objectionable, as long as the opinions respecting the supposed symmetry and equality of the natural divisions of animals, entertained at present by many scientific men. continue to prevail; and until the inequality of endowment characteristic of all organized beings is recognized as the law prevailing in the organic kingdoms, from the humblest individual to the most comprehensive types.

My opportunities of investigation do not justify me in attempting to characterize all the genera of the order of Testudinata. I must limit myself, in this part of my subject, to a general review of those which have representatives in

North America, introducing only such comparisons with foreign ones as may be imperatively required to appreciate their mutual relations.

All the genera thus far established among the Chelonii have representatives along the coast of the United States, and I am not aware that there are any genera of this sub-order, except those which have already been recognized by herpetologists: the family of Sphargididæ, containing only one genus, the genus Sphargis; and the family of Chelonioidæ proper, containing three genera, namely, Chelonia, Thalassochelys, and Eretmochelys. But as some of the most prominent herpetologists recognize only one genus in this family, I will give below my reasons for believing that the genera Thalassochelys and Eretmochelys are as well founded in nature as the genus Chelonia proper.

Of the sub-order Amydæ, the family of the Trionychidæ has only four representatives in America, which however bear a very peculiar relation to the other members of the family; for while all the Trionyx of the old world are inhabitants of the tropical fresh waters, or at least occur only south of the twenty-first isothermal line, those of America are all found to the north of that very line, neither Central nor South America nourishing a single Trionyx, while in North America they range over the whole continent east of the Rocky Mountains, as far north as the great Canadian lakes and the upper St. Lawrence.

If we were to judge by the opinion prevailing about the Chelydroidæ a few years ago, it would appear that we had only one species of that family; and yet Dr. Holbrook, in his North American Herpetology, long ago described a second species, under the name of Chelonura Temminckii, which seems to have remained unknown to European writers, for all their references to this animal are either expressed with doubt, or are evidently mere compilations, or abstracts from the North American Herpetology. I have now in my possession a number of specimens of this species weighing between ten and fifty pounds, preserved in alcohol, and also several skeletons made from specimens presented to me by Prof. Baird, Prof. Chilton, Dr. Gessner, and Winthrop Sargent, Esq. I had, besides, an opportunity of seeing two living specimens in their native waters, in the neighborhood of Mobile, one of which weighed about two hundred pounds, and many others which were sent to me alive by Mr. Sargent and which I preserved alive during the whole of last summer. I have, in addition, examined several very young ones, preserved in alcohol, which were forwarded to me by Prof. Baird and Dr. Nott. I can, therefore, not only vouch for the specific distinction of the two species, but am prepared to show that they differ generically, as a fuller comparison below, illustrated with many figures, will prove. (See also above, p. 248.)

The family of the Chelyoidæ has no North American representatives, nor has that of the Hydraspididæ; but of the family of the Cinosternoidæ we have two genera, one of which is the well characterized genus Cinosternum of Spix. The opportunities I have enjoyed for the examination of the representatives of these genera have satisfied me that the sexual differences among them are such as readily to be mistaken for specific differences, which has actually been done again and again. The tail of the male, for instance, is always much longer than that of the female; the males have sharp asperities between the joints of the hind legs; moreover the color and ornamentation differ considerably. As a genus, however, Cinosternum is easily distinguished. Yet our common Mud-Turtle, (Ozotheca odorata,) has been referred to Cinosternum by some authors, and to Sternothærus by others, until it was placed in the genus Staurotypus by Duméril and Bibron. Having formerly had an opportunity of examining, in Munich, the type on which Wagler founded the genus Staurotypus, I can affirm that our species is by no means generically identical with Wagler's Staurotypus, and still less belongs to Bell's Sternothærus, or to Spix's Cinosternum. It constitutes, indeed, a genus for itself, which I have called *Ozotheca*, the characters of which are intermediate between those of Staurotypus and those of Cinosternum. There are, in the southern parts of our country, other species of this genus, as I have had good opportunity of ascertaining, but I have no hesitation in saying that the characters according to which some of the species now admitted have been established in this family by Wagler, Duméril and Bibron, Gray, and LeConte, may all be found upon specimens of different age, sex, and size, living together in the same pond in our Northern States, so that the true differences of our species are still to be pointed out.

All herpetologists seem to agree about the limits of the genera Emys and Cistudo, though they differ about the name, Canino retaining the name of Terrapene for the group to which Duméril and Bibron assign the name of Emys, and giving the name of Emys to that group which Duméril and Bibron call Cistudo, and which Gray farther subdivides into Cistudo proper and Lutremys. The descriptions of our species below will show that the distinction introduced by Gray is truly founded, and that Cistudo and Lutremys are not only sub-genera, but constitute entirely distinct genera belonging even to different sub-families. As the name Cistudo was first assigned to the Cistudo carolina, it is proper it should retain it, while it is equally proper that the group to which Gray assigns the name Lutremys should be called Emys, as it includes the European Emys, upon which the genus Emys was founded by Brongniart. More than twenty years ago, Canino had already called the attention of herpetologists to this point, and set it all right; yet no one has followed his suggestion, thus far. Accordingly, there exists in North America not a single Emys, properly speaking, among those which have been described under that generic name. Moreover, the species which have been referred to that genus do not, by any means, all belong to one and the same genus.

Since I have had an opportunity of comparing all the North American Testudinata with one another, alive,[1] I cannot cease to wonder that the marked generic peculiarities of the Emydoids should have been so entirely overlooked. I have already stated (p. 246) that the so-called Cistudo Blandingii is a true Emys; it is the North American representative of the common European Emys (Lutremys, *Gray*.) Now that its natural relations are accurately determined, it should henceforth be called Emys Meleagris, as this specific name is older than that of Blandingii. But, among the other North American Emydoids we find several other generic types. Emys scabra (serrata), Troostii and elegans (cumberlandensis) constitute a distinct genus, which I call TRACHEMYS; whilst Emys mobiliensis, concinna (floridana), and rugosa (rubriventris) constitute another genus under the name of PTYCHEMYS; and Emys geographica and Lessueurii (E. pseudo-geographica) still another under the name of GRAPTEMYS. Emys picta, Bellii, and several new species, constitute also a distinct genus, already recognized by Gray, and called by him CHRYSEMYS. Emys guttata is also the type of a distinct genus, which I call NANEMYS. Emys Mühlenbergii is the type of the genus I have named CALEMYS, and Emys concentrica constitutes still another genus, already named MALACLEMYS by Gray; this and Chrysemys being the only ones thus far noticed as generically distinct from the other types of Emydoids inhabiting North America. Emys reticulata constitutes also a new genus, DEIROCHELYS; Emys insculpta another, GLYPTEMYS; and Emys marmorata *B.* and *G.* (E. nigra, *Hal.*) still another, ACTINEMYS. The North American Testudinina belong to the new genus, XEROBATES. All these new genera and several new species, peculiar to the United States, are characterized below.

SECTION III.

ESSENTIAL CHARACTERS OF THE ORDER OF TESTUDINATA.

There is scarcely any order among Vertebrates so well defined and so naturally circumscribed as that of the Turtles. The cycle of their modifications, notwithstanding the diversity of sub-orders, families, and genera which they include, is so narrow, the external systems of organs, even the proportions of the body, are so

[1] The number of living turtles I had an opportunity of examining and preserving for months and years in my yard, will appear incredible to European naturalists. I have had them and their eggs by the thousands, thanks to the kindness of my friends in every part of the country; and I shall avail myself, in the next chapter, of the opportunity duly to mention all these favors, when enumerating singly all our species and the precise localities where they are found.

constant, that even the uninitiated will recognize a Turtle as a Turtle, as readily as they will know a Bird to be a Bird.[1] It is not so with the other orders of Reptiles, the Snakes and Lizards. It is certainly easy to recognize in a Rattlesnake and a Leguan two entirely different animals, but it needs a scientific investigation, and indeed a very accurate one, to distinguish the Rhinophis as a Snake, from the Anguis or Ophisaurus as a Lizard; indeed, in English, the Ophisaurus is commonly called a Snake, the Glass-Snake. All Turtles, on the contrary, are distinctly comprised by all civilized languages under one name. What, then, is this something which so forcibly strikes the eye of the unlearned, and is so graphically expressed by the familiar names of these animals? It is the stiff backbone, spreading into the shape of a shield: Schild-kröte, German, shield-toad; turtle, Saxon, perhaps from tart or tartsche, the shield of the old Germanic tribes; testudo, in Latin.

Let us now consider, from this point of view, the remaining orders of the Reptiles, the Serpents and Saurians, and we shall see what deep truth is hinted at by this name of "Schild-kröte." The Snake moves only by means of the lateral motions of its vertebral column, together with the ribs; the Turtle only by means of its feet; and the Lizard, which stands between the two, by means of both together. We have a gradual series from the Apodes, or footless Reptiles, which creep upon the stomach, the Snakes, through the Lizards, up to the highest Reptiles, namely, the terrestrial Turtles, which stand upon four supports; and, to gain a true insight into the characters of the order of Testudinata, it is important to trace this series through its successive links. In so doing, we find the Pythons moving like all other serpents by means of horizontal undulations of the vertebral column, and the pressure of the ribs attached to it. But the anatomist finds, concealed under their anal scales, traces of hind feet, and even of the pelvis. These rudiments of limbs have as yet no locomotive function, but they hint at what is afterwards to appear in the higher types of the same class. The lowest Lizards, (and every zoölogist considers as such the family of Glass-Snakes, Scincoidæ,) begin with the European Anguis, in which traces of hind feet are concealed under the skin, but the only real

[1] Simple and trivial as this statement may seem, it involves a principle which neither naturalists nor general observers appear yet fully to understand, namely, that natural groups are not necessarily equally distinct, and that groups which seem equally distinct are not necessarily of the same value. No higher group in the animal kingdom is more clearly defined than the class of Birds, with perhaps the sole exception of the Turtles; but then Turtles constitute only an order in the class of Reptiles, and not a class for themselves; while the Reptiles as a class by no means present that uniformity of appearance so characteristic of the Birds. What is true of these two types within their limits is equally true of hundreds of other types within other limits. Much of the uncertainty perceptible in our classifications, from the highest divisions down to the limitation of the species, arises from a constant neglect of the universal inequality which pervades both the animal and the vegetable kingdoms.

locomotive organ of which is still the vertebral column with the movable ribs, as in the Snakes. In the Dibamus of New Guinea, there appear, for the first time, visible extremities, small, slender, toeless, scaly hind feet. In the Bipes of New Holland these become somewhat larger, and in Brachymeles, rudiments of anterior extremities are added. In the genus Evesia, these extremities are still undivided; in the Brachymeles proper they have, in front and behind, two toes; in the South-European Seps, we find already three toes in front and behind; in the Scincus five,[1] in front and behind, but the fore feet are still weak and do not yet carry the body so swiftly and easily over the earth as those of the Lizards, but these also, with their perfectly developed feet, are still assisted by the motion of the vertebral column. From this point of the series up to the Turtle, there is a great stride, for in them the head and neck are free, much freer than in any of the Saurians whatsoever. The vertebral column has become stiff; the four feet are the only locomotive organs; and yet in the marine Turtles, the fore feet exceed greatly in power the hind pair, and it is only in the land Turtles that we find at last all the four feet perfectly equal in strength, affording four props or supports, upon which the whole body moves slowly forward, like a house on rollers.

This is the natural series of the orders in the class of true Reptiles. Let us now consider the class of Amphibians from the same point of view. The Cæcilia, the lowest Batrachian, is a long-drawn, serpent-like animal, moving by means of undulations of the vertebral column. In one of our southern Ichthyoid Batrachians, called Siren, there arise two feeble feet in front, or rather a pair of diminutive anterior limbs project from behind the gills. In the German Proteus, or the North American Amphiuma, four legs are already perceptible, having from two to three toes, and the Salamanders, which at present extend over the whole surface of the globe, walk, like the Lizards, on four well developed feet, using like them, however, the whole dorsal column as a locomotive organ. From these, again, we have a stride up to the Frog. The spine has become stiff; all lateral motion has ceased in it, and, as in the Reptile when in its highest development, so with the most perfect Batrachian, the four feet are the only locomotive organs. This is the series of the Amphibians.[2]

If we now compare the highest Reptile, the Turtle, with the highest Amphibian, the Frog, the locomotive organs in both being completely developed, and the spine serving no longer for locomotion, we find the latter ready to be applied to other purposes. A step towards this is made in the Frog. The caudal bone is separated sharply and distinctly from the rest of the spine, as is also the neck,

[1] For further details respecting the series of the family of Scincoids, see Part I., Chap. 1, Sect. 12.

[2] Compare the illustrations of this series in my Lectures on Comparative Embryology, p. 8 to 10.

but both are still buried, as it were, in the general mass of the body. On the contrary, in the culminating Reptile, the Turtle, the neck is completely free from the mass of the body, and so also is the tail; but there is still a sort of visceral chest, inclosing the breast and abdomen.

This general sketch of the essential characters of the Testudinata shows distinctly that their most prominent features are also those which assign to them the highest rank in their class. It is therefore plain, that the Testudinata, being a natural group, constitute an order in the class of Reptiles, acknowledged to be such by most zoölogists, while at the same time this typical group furnishes additional evidence that the characters I have considered above[1] as ordinal characters are marked out, as such, in nature. It remains now to show, what is the degree of complication of their structure which assigns to them that rank in their class. The comparison instituted here, between the leading groups of the true Reptiles and those of the Batrachians, shows already the two series to consist equally of groups presenting a natural gradation in their normal relations. We are, therefore, not only justified in considering them all as natural orders, but this gradation, within their respective limits, goes far also to show that the higher divisions under which they are combined partake of the character of classes, and that Reptiles proper and Amphibians are justly to be considered as two distinct classes.

SECTION IV.

THE SHIELD.

We have found the main ordinal character of the Turtles, in contradistinction to other Reptiles, to consist in the nature of the dorsal column, which, in connection with other elements, forms in Turtles one continuous shield upon the back. This dorsal shield, usually called by the French name "carapace," is connected by a bridge with another shield, commonly called "plastron," which covers the region of the breast and abdomen from below. These two shields together form a hard girdle around the soft organs of the trunk.

If we take a Turtle of that family in which the idea or the type of Turtles is carried out the furthest, namely, a land Turtle, we find these shields built up of two very different elements, the skin and the true bony skeleton. If we analyze such a shield from the outside inwards, we see first a thick very hard and dry epidermis

[1] Part I., Chap. 2, Sect. 3, p. 150.

with its thin, soft, and wet matrix, the stratum Malpighii. Then, immediately under this, we find a bony plate. Now this bony plate consists of two elements, very different in their anatomical and physiological character; namely, first, of parts of the true skeleton, the vertebræ, the ribs, and the bones of the sternum; secondly, of ossifications of the skin, or rather of the outer walls of the body, which overlie the true skeleton and fill out its framework, thus making one continuous bony shield of the vertebræ and ribs, and another of the sternal bones. These ossifications of the skin, commonly called the dermal skeleton, are divided into many fields, like a pavement, by sutures, the direction and extension of which are entirely independent of the underlying framework of the true skeleton. These fields are larger where they overlie the bones of the true skeleton; they become smaller and thus relatively more numerous where they reach beyond it, namely, in the margin of the upper shield. As already stated, these marginal bony plates are mere ossifications of the skin extending beyond the ribs. The relative direction and extension, as well as the number of all these fields of the ossified skin, are very similar in the different families of Testudinata.

This composition of the shield, from the elements described above, is common to all the land Turtles, to the Emydoidæ, to the Cinosternoidæ, to the Chelydroidæ, and to the South American, Eastern, and Australian Pleuroderæ, the Chelyoidæ and Hydraspididæ. Thus far, we know only three groups which present any differences in these respects, the Chelonioidæ, the Sphargididæ, and the Trionychidæ. Though we find that in the Chelonioidæ all the elements named above take part in building up their shield, still their dermal skeleton is very much reduced, while in land Turtles it makes up by far the largest part of the bony shield and actually grows into the true bony skeleton at the expense of the latter, in such a manner that parts of this disappear and are replaced by the ossification of the skin. In the Chelonioidæ, on the contrary, the dermal skeleton fills only imperfectly the spaces between the ribs, but then it forms a regular row of marginal plates, and again scantily fills the spaces between the sternal bones. In Trionychidæ, we observe the same partial development of the dermal skeleton, as it fills only to some extent the intercostal spaces and the spaces between the sternal bones, and forms but a few marginal plates, which may even be entirely wanting, as is the case in the Southeast African Cycloderma, recently discovered by Dr. Peters, and in our own Trionyx ferox and muticus. Finally, in Sphargis the dermal skeleton is developed in a very different way, namely, as one continuous shield above, and another beneath, nowhere resting immediately upon the true skeleton, there remaining between the dermal and the bony skeleton a thick layer of corium, which never ossifies. This structure constitutes the most striking contrast when compared with Testudo, where the dermal shield actually grows into the true bony skeleton. Thus it appears that in Sphargis the trunk is inclosed in a dermal bony girdle which is circumscribed in front, behind, and on the two sides; under this solid envelope follows a coarse felt of soft corium without lime deposits, and under this finally lies the true skeleton. In Sphargis, the ossifications of the skin have thus least to do with the skeleton proper, while the connection of the dermal and the true skeleton is carried furthest in land Turtles. We may say, therefore, that if the type of Turtles is carried out the furthest in the genuine Testudinina, it is the least so in Sphargis.

SECTION V.

THE SKIN.

The epidermis, the Malpighian layer, the corium, and the ossifications of the latter, are to be found in all Turtles, but they show the greatest variety in different. families. We will analyze these different strata, proceeding from the outside inwards.

The Epidermis. The epidermis of the head is of great importance in characterizing the order, the sub-orders, families, genera, species, and even the sexes of Turtles. The practised observer may, from the sheath of the jaw alone, recognize at least the genus. In all Turtles, the jaws are covered by a thick epidermis, which gives them the appearance of a genuine bill, more or less rounded in front, with sharp margins either smooth or denticulated. Such a bill is not found in any other Reptile, nor in any order of Vertebrata, except in two Mammalia, in all the Birds, and in the Tadpoles of the Batrachians. This horny sheath is erroneously said to be wanting in some Turtles. We find it in all, even in the Trionychidæ, where the jaws are covered by fleshy lips, but it varies greatly in thickness; while it is rather thin in the Emydoidæ, it forms in the Cinosternoidæ a strong, sharp hook, which is stronger still in Chelydra, and strongest in Sphargis, which is very likely a carnivorous Turtle. In this last genus it has the form of a hook bill, more powerful than even the bill of the South American Harpyia.

On the top and on the sides of the head the epidermis forms either one continuous layer, as in the Emydoidæ, Cinosternoidæ, Chelydroidæ, and Trionychidæ, or it is divided into a pavement of thicker plates, disposed either symmetrically, as in Chelonia, or more irregularly, as in Testudo. On the under surface of the head, on the chin and upper neck it is seldom thickened into distinct plates, but, no doubt in order to provide for its greater movability, it is usually only divided by wrinkles into fields, as it is also all over the neck and in all those other parts of the trunk which are not covered by the shields of the back and the lower side. The epidermis of the legs varies very much, from the thin layer of the Trionychidæ, in which it is only in some single places thickened into hard plates, to the horny, scaly, or plated stiff coat of the massive feet of the sea and land Turtles, Chelonia and Testudo, where there is very little or no motion of the different parts of the legs. In the Chelonioidæ the epidermis of the last phalanges appears as a nail only in the thumb, while in Sphargis there is not even a trace of a nail to be found; in the Trionychidæ it forms sharp, long, slim claws, in three fingers and in three toes; in the aquatic Emyds (Nectemyds) there are similar nails in all the fingers and in the toes. On the contrary, in the more terrestrial members of the family of Emydoidæ, in Glyptemys insculpta, and still more in Cistudo, whose fingers and toes are less movable and frequently used for walking on land, the claws appear shorter and stouter, while in Testudo the whole coat of the fingers and toes has become a hoof, almost as in Pachyderms, serving as in the latter to carry the heavy load of the body. These epidermal formations in the legs and particularly those in the last phalanges, in connection with the epidermal formations of the jaws, are very important for the classification, as they indicate more clearly than any other external organ the mode of life of the animal in all its relations to the outer world. That the consideration of these parts leads really to natural divisions is seen not only in Turtles, but more distinctly still in Birds and Mammalia; and the system of Linnæus, founded upon such details, has assumed the character of a natural combination in the classification of these two classes, though, as he understood them, they still appear as artificial as his system of plants.

The epidermis of the tail is mostly wrinkled or covered only by small scales, thus allowing to this organ a great movability. In the family of Chelydroidæ only do we find, along the top of their long, powerful tail, a row of hard tubercles strengthening and protecting it as an organ of locomotion, and by no means interfering with its movability. In some land Turtles and in the genus Cinosternon, the end of the tail has a flat, rounded sheath, as in Testudo indica, or it has a pointed nail-like or even crooked tip, as in Cinosternon, particularly in the males.

The most important features of the epidermis, and those most peculiar to Turtles, are found in the back and the lower shield. It is scarcely developed in two families, the Trionychidæ (soft-shell Turtles) and the Sphargididæ, in which it forms only a thin continuous layer upon the corium, as in naked Batrachians, while it is thick, horny, and divided into fields in all other Testudinata, that is to say, in all those Turtles in which the corium is entirely ossified. In the Trionychidæ and Sphargidæ there lies always a thick layer of soft, unossified corium, under the thin, elastic epidermis. As in all Vertebrata, so also is the epidermis in Turtles, composed of characteristic cells, of an hexagonal or irregular form, which are dry and flat near the surface, and more or less imbricated, while their contours are better defined the deeper we penetrate and the more we approach their matrix. But in relation to the mode of growth and the duration of these cells, upon a larger scale, up to the time when they are cast in moulting, we find the greatest variety among Turtles, as we find, indeed, among all the different types of Vertebrata. The differences in the epidermal formations, observed in Turtles, naturally lead us to expect such a diversity among them in particular. In the Sphargididæ and the Trionychidæ, I have had no opportunity of seeing a regular casting off of the epidermis, though there can be hardly any doubt that a change of the epidermis takes place here, and that it is effected by the dropping of single cells or of thin layers, for I have noticed it in Trionyx, as we find it in the epidermis of Frogs and of Man himself, in whom it is quite similar. But in all other Turtles, the nature of the epidermis, and therefore its moulting also, are entirely different. In Eretmochelys imbricata, the plates of the shield (the tortoise-shell of commerce) are very large, and imbricated one above the other. These plates increase only in front, where they are imbedded in a thick matrix, in the Malpighian layer, as in a case. As the plates enlarge in front, the older parts must move backwards, where they are worn off by external mechanical agencies. This process goes on so rapidly in these Turtles, that in a specimen of two feet in length, no trace of those primary scales, which covered the whole shield during the first year, could be found. This mode of growing and moulting, if we may call it so, is very similar to that in the human nail. But we find a very different process in land Turtles, and to some degree also in Cistudo, in which the plates rest entirely, in front and on the sides and behind, upon their matrix, in the Malpighian layer. They are not at all free and raised behind, as is the case in Eretmochelys, and thus they grow not only in front, but with their whole under surface and on all sides; hence it follows that we find upon the surface of each scale, around a small angular central plate, (the scale of the first year's growth,) a smaller or greater number of concentric stripes or regular annual rings, as they are exhibited on a transverse section of an old tree.[1]

[1] This is remarkably obvious in some specimens of the Xerobates carolinus (Testudo polyphemus) of our Southern and South-western States, and always in Testudo radiata of Madagascar, and in Testudo geometrica of the Cape of Good Hope. In relation to the Gopher, (Test. polyphemus,) I have to remark that the plates of most adult specimens are perfectly smooth, so that their successive growth and their age can no longer be read upon the plates, as it is easy to do in many other species of that family. The Gopher, and perhaps also the Galapagos Turtle (T. indica) burrow into the ground and live in earth holes, and this accounts, perhaps, for their worn and polished plates. But why should

Thus we have two different modes of growth in the dermal plates of Testudinata: that of Eretmochelys on one hand, and that of Testudo on the other. Between these extremes, we have every possible intermediate feature. Thus, we find that in the Chelonioidæ and Emydoidæ, though the plates are not free behind as in Eretmochelys, but on the contrary lie with their whole under surface upon the stratum Malpighii, as in Testudo, they still grow almost exclusively in front and on the sides, showing only small additional stripes behind, or none at all. This is still more strikingly exhibited in the Cinosternoidæ, and here it is in the direction of the Eretmochelys, as they show an evident inclination to an imbricated position of their plates. It is already visible in Cinosternon, especially in Cinosternon flavescens, but still more in the Ozotheca triquetra of our Southern States, and also in our Northern Ozotheca odorata, when young. I have already had occasion to allude above to the moulting of the epidermis when speaking of Sphargis, Trionyx, and Eretmochelys; but I am persuaded that such a change in fact takes place in all Turtles. In Chrysemys picta, and in several other fresh-water Turtles, such as Trachemys elegans and scabra, Ptychemys concinna, Graptemys Lessueurii, etc., I saw in the spring the uppermost layer of the dermal plates cast off at once as one continuous, thin, mica-like scale all over the plate, and under it the fresh epidermis, showing beautifully by its transparency the colors of the Malpighian layer. This reminded me very much of the moulting of Snakes; but the difference consists in this, that in Snakes the epidermis is cast off as one continuous skin from the snout to the end of the tail, while in Turtles each scale casts its epidermis for itself. In Testudo, the casting off of the old epidermis is very different in different species, and even in different specimens of the same species.[1] I have seen in many adult specimens of Xerobates carolinus, and still more distinctly in some old specimens of Testudo radiata, the central plate of the scales, that is the plate of the first year, perfectly preserved with all its fine granules, so sharp indeed that it seemed as if nothing had been cast from their surface, while others were entirely worn out. These facts show that further observations are very much needed respecting the moulting of the Reptiles. Indeed, this subject requires to be studied anew in all Vertebrata.[2]

other specimens of Gopher, which have the same mode of life, exhibit all the sculptures of their plates? We find the same difference between the specimens of Cistudo virginea, and still more between those of Glyptemys insculpta, the smooth variety of which has been described as a distinct species under the name of E. speciosa.

[1] See, above, p. 259, note on Gopher and Cistudo.

[2] I mean here particularly also the moulting of Mammalia and Birds, which is by no means so fully understood as it would appear from our handbooks. D. Weinland has presented interesting remarks upon this subject in a paper read before the Boston Society of Natural History in the beginning of this year. See the Proceedings of the Boston Society of Nat. Hist. for 1856.

The Colors in Turtles. The coloring of the lowest strata of the epidermis, the so-called Malpighian layer, has not yet, so far as I know, been the object of a special investigation. I deem it, therefore, worth our while to take up this point more fully than other parts of the ordinal characters. The uppermost dry part of the epidermis, the stratum corneum, which is so extensively developed in Turtles, exhibits as usually by far the smallest part of the colors; the most beautiful colors being included chiefly in the Malpighian layer. That stratum, on the contrary, is transparent, with a grayish lustre, like mica. Thus far only one Turtle is known in which this dry, horny layer contains all the coloring matter, at least as far as the colors are visible from outside, namely, Eretmochelys imbricata; and it is owing to this extraordinary circumstance that in the dry plates of this Turtle (the tortoise-shell) all their beautiful colors are preserved, even after the plates have been removed from the Malpighian layer. A homogeneous brownish lustre may be seen with the microscope in the epidermal cells, in all those places of the plate where it appears brown; there is, however, no trace of pigment cells, nor of any fluid, and that brownish color belongs only to the walls of the cells.[1] Still more intense colors, often black, produced in the same way, are found in the thick plates of nearly all land Turtles, for instance, in Testudo radiata, polyphemus, indica, etc., and in some Chelonioidæ, as in Chelonia Caouana and Mydas, but in all these the Malpighian layer, lying beneath the plates, also takes part in forming the colors which appear outside.

The Malpighian layer, also called the pigment layer, is not only the matrix of the epidermis, but at the same time the bearer of the pigment in Turtles. It is moist and soft, and of very different thickness in different families, generally however thick enough to be readily separated as one continuous membrane from the dry, horny stratum which lies above it, as well as from the corium or bone which lies below. It is composed of large, round, transparent cells, lying not in plane layers, but rather imbricated. On, between, and beneath these cells lies the pigment, either in cells or as a free fluid in lacunes, or in one continuous layer. Thus we have to distinguish two different forms, under which the pigment occurs in Turtles: first, real pigment cells, which are always black or blackish brown, and filled with brownish pigment molecules, upon the amount of which in a cell depends its more or less dark tint; and secondly, a colored oily fluid, moistening generally the whole Malpighian layer, and not contained in regular cells. Under this second form appear the most various colors, such as the yellow, red, brown, and also sometimes black tints of our different kinds of Turtles. The most diversified play of colors is produced by the combinations of these free fluid colors, by their superposition

[1] As we find it also in some places of the human body. See Kölliker Gewebelehre, p. 98, § 43.

and by their separation through cells of the Malpighian layer. Generally this fluid is again combined with the pigment cells described above, the forms of which, more or less radiated, more massive or more slender, produce again different effects. Under the microscope, the free fluid coloring matter looks generally yellowish, if the effect is yellow; reddish, if the effect is red. Water added to this fluid when taken from the living specimen, causes it to collect in larger and smaller drops, and then their oily character[1] becomes evident by the characteristic blackish margin of the drops. We have still to mention another kind of color, which we see only in one genus of North American Turtles, namely, the white on the head of some specimens of the genus Cistudo. This appears under the microscope to be composed of grayish black heaps, and if these are farther isolated, we find them composed of thin transparent plates, breaking like glass. All these pieces together produce the impression of a white tint upon the eyes, by interference of the rays of light, just as the powder of glass, the smallest pieces of which are also transparent under the microscope.

The range of variations which the colors exhibit in one and the same species, in many genera of our Testudinata, is almost incredible; and unless these variations are carefully studied, and their transitions watched for a long time, in every stage of growth, it is impossible to know how far they agree with the natural limitation of species. For this reason most descriptions of the colors of our Turtles are incomplete and unsatisfactory, being generally drawn from a few specimens. In several instances, nominal species have been distinguished merely upon differences in the coloration. This has been done to the greatest extent in the genus Ptychemys, as we shall see hereafter. Generally speaking, there are, however, certain tints which prevail in some species, while other tints are more common in other species, and in these cases the colors afford, to some extent, good specific characters. But it sometimes happens that not only the patterns of coloration, but even the colors themselves, are the same in every species of the same genus, so that coloration requires a special preliminary and extensive study for every genus, before it can be applied to the systematic characteristics of these animals.

[1] In relation to the nature of this oil, see D. Weinland on Birds' Feathers, in Cabanis, Journal für Ornithologie for 1854. He supposes that the yellow oil turns reddish by a kind of oxydating process, and thus, perhaps, also the reddish to brown, and this to black. Such an oxydation takes place, as we know, for instance, with extravasated blood, which turns black very likely by a process of burning. It is true, this is a pathological experience, and it may not seem proper here to refer to it; but pathology rests upon the same laws of organic chemistry as physiology. For studying these colors in Turtles, we recommend as fine objects the red and yellow rings on the marginal plates of Chrysemys picta and marginata. The beautiful brown-green color of the dorsal shield of the latter is produced by a network of black lacunæ lying on a homogeneous layer of yellow oil.

The Corium. A thorough analysis of the corium is of the greatest interest in the study of the Turtles, because this part of the skin is the seat of all those deposits of lime which compose their dermal skeleton. The corium is composed of two very different layers: first, a layer of elastic fibres, immediately under the stratum Malpighii, consisting of the same kind of anastomozing, or rather net-like, elastic fibres that we find in the walls of the arteries, etc.; secondly, a layer of a tissue consisting of smooth, long fibres crossing each other, and interwoven sometimes more regularly, as in the Trionychidæ, or irregularly, as in Sphargis. According to the numerous sections which we have made, a deposition of lime generally takes place only in the elastic fibres, while the fibrous tissue lying beneath is resorbed. At least we find in all ossifications, when young, the arrangement of elastic fibres still very distinct; and Sphargis, in which a bony shield of about two lines in thickness begins immediately under the Malpighian layer, seems to show this particularly well. Under this follows a thick, coarse, fibrous tissue, in which there are no ossifications at all; under this, finally, follows the skeleton. In sections made in different directions through the shield, we see clearly the character of the ossifications, as well as that of the skin which does not ossify, and that of the skeleton proper, which in most Turtles is very much affected by the ossification of the skin. A section through the soft but thick margin of the dorsal shield of Trionyx ferox, in which no ossifications take place, shows first a thin epidermis, then a thicker layer of elastic fibres, then many layers of fibres crossing each other regularly and producing by the regularity of their knees those seeming layers of the skin which are so striking to the naked eye in any transverse section. Another section through a dermal ossification of the sternum of the same Turtle, shows the difference between the true skeleton bone, with its very regular structure, bone-holes, etc., and the dermal bone above it, in which many canals run through, piercing it in different directions, and in which the bone-holes also are more irregularly disposed, showing its origin from elastic fibres. This is still more evident in a section through a younger ossification in Chelonia Mydas, where the roundish or longitudinal holes of the elastic fibres are very distinct. Again, another section near the former, where the ossification has not yet begun, shows the character of the elastic tissue when it is about to be ossified. A horizontal section through the bony shield of Sphargis, which, as stated above, nowhere touches the bone, is also very characteristic. This structure furnishes of itself sufficient evidence of the incorrectness of the views which Cuvier[1] and others entertained, that the whole bony shield of Turtles is pro-

[1] Without making any distinction between the dermal and the true skeleton, Cuvier (Leçons d'Anatomie comparée, 2d édit., vol. i., p. 263, and Ossements fossiles, vol. v., 2d part, p. 195), and with him also Geoffroy, (Mém. du Muséum, vol. xiv.,) consider the carapace as formed entirely by the dilatation of the vertebræ and the ribs. Carus (Urtheile, etc., p. 150) was the first to show that a considerable portion

duced by a mere enlargement and overgrowing of the vertebræ and the ribs, that is to say, by the peculiar development of certain bones of the true skeleton.

The bony shield of Sphargis exhibits, moreover, some peculiarities which we do not find in other Turtles. There is a most elegant pavement of small plates, extending over the whole shield, seemingly jointed to each other by the finest sutures, which, however, are in fact nothing but nutritive canals starting from those seeming sutures, themselves larger canals, and ramifying through the plates as a fine network of a yellow color, owing to the fat fluid which the canals contain. As I possess no young specimens of this Turtle, I have had no chance to observe the corium before it is ossified, so that this remains to be studied. The character of the ossification is, however, really the same as in the dermal ossification of Trionyx, mentioned above, except that the canals seem to be more regular in Sphargis. With reference to the extension of these ossifications, I have already made some remarks above, when speaking of the bony shield generally.[1] I have now only to condense all the observations related above, in a few words.

The ossifications of the corium in Turtles take place only in the dorsal and ventral walls of the body. Their development is greatest in land Turtles,[2] and least in the Trionychidæ and Sphargididæ; in which latter, though they are relatively more extensive than in the Trionychidæ, they yet nowhere reach the true skeleton. The deposition of lime in these ossifications is mostly so extensive, that they are just as hard as true bone, and in proportion to this deposition of lime, their structure approaches also more and more that of true bone, the holes of the elastic membrane appearing then as haversian canals, and around them the fine bone-holes, but it shows still everywhere its character as dermal bone by the irregularity of its structure. In order to ascertain what is true skeleton bone, and what dermal bone, I have availed myself not only of the difference in their structure, but resorted also to the investigation of the cartilaginous skeleton in the embryo, or in the young soon after hatching. Such young Turtles furnish, indeed, the most beautiful microscopical objects for the study of cartilage and its ossifications. Now wherever we find regular cartilage in the young, we take it for granted that such parts are to be considered as belonging to the true animal skeleton. Thus we have ascertained

of the so-called skeleton of the Testudinata is formed by the skin. This has been further illustrated by W. Peters (Observationes ad Anatomiam Cheloniorum, Berolini, 1838) and by Owen (Observations on the Development of the Carapace and Plastron of the Chelonians, Philos. Trans., 1849, and Fossil Reptilia, Palæontographical Society, 1849). The most striking evidence of the independence of the dermal and the true skeleton is afforded by the solid frame of Trionyx, in which the growth of the dermal and of the true skeleton takes place by an alternate extension of their respective peripheric parts, as we shall see fully when considering this family more in detail.

[1] See, above, Sect. 4, p. 255–257.

[2] It is in this sense that the statement on page 236, line 22, is to be understood.

that all the nine sternal bones of the Turtles are not mere dermal ossifications, as Rathke,[1] misled by the attachment of the muscles inside, would suppose, but that they really belong to the skeleton, being regular cartilages with distinct forms, and of the same shape as the bones in the adult. In the same way we have ascertained that the marginal bones are mere ossifications of the skin, and by no means to be compared with the long bridges which connect the true ribs and the sternum in Birds, as Geoffroy, and after him, Duméril and Bibron, believed.[2] We found, farther, that that strange crosspiece, the foremost transverse bone in the carapace, is a regular skeleton bone, though I do not venture to call it either a rib or a transverse process of the last neck vertebra, as one might perhaps think it to be. There are limits to explaining and homologizing. We cannot make up a Bird from the bones of a Turtle, nor a Man from the bones of a Fish, as some anatomists have recently tried to do, who misunderstood the great thoughts of Oken and other philosophers respecting the structure of the skeleton.

If we go back to the earliest stages of growth of the Testudinata to ascertain the true character of their bony shield, it will be easy to show that the bony walls which, in the adults, form the dorsal and pectoral shields, consist at first simply of cells, out of which the skeleton, the muscles, and the skin are formed in the end, in all Vertebrates, and that it is not the skin only which is here absorbed into the skeleton, but the whole animal wall. This view of the case may render more intelligible the apparently abnormal position of the limbs, and the mode of attachment of the pectoral muscles.

SECTION VI.

THE SKELETON.

Head. The skull in the Turtles is more solid and compact than in the Saurians and Ophidians; the bones of the face, in particular, are immovably fixed to the skull-box; the os quadratum is also soldered to it by a tight suture as in Crocodiles and in Mammalia, while in the other Reptiles and in Birds it is jointed to the skull only by ligaments and a socket. The lower jaw is formed of one solid, bony arch, the soft symphysis between its branches having entirely disappeared as in Birds, while in Saurians this symphysis always remains more or less carti-

[1] See Rathke, Ueber die Entwickelung der Schildkröten, p. 122.

[2] Geoffroy, in Annales du Muséum, vol. xiv. Duméril and Bibron, in Erpétologie générale, vol. i.

laginous, and in the Ophidians it is so elastic as to allow the branches to move far apart one from the other.

This solid conformation of the head shows, again, the high standing of the Testudinata, for the loose connection of the bones of the head is a character peculiar to Fishes, while the solid, compact skeleton of the head is characteristic of Mammalia. There is still another feature in the head of the Turtles which gives it a general interest: the great similarity of the hind part of the skull to a vertebra. The resemblance of the os occipitale basilare to the body of a backbone, and of the ossa occipitalia lateralia to an upper arch, is more striking than in any other Vertebrate. The bones around the brain are flattened; the parietal bones inclose the brain from above and from the sides, the wings of the sphenoid remaining relatively small. There are two pairs of frontal bones; the exterior ones are generally, though not always, united by a median suture, and cover the nasal cavity from behind. There are no nasal bones, except in one genus.[1] In the fresh animal, the condylus occipitalis is a nearly round prominence with a depression in the middle, in which the second vertebra articulates; when dry it is triangular. In the dry skull the composition of this condylus, formed from one basilar and two lateral occipital bones, is evident by the sutures. This structure is the same as in the true Saurians and Ophidians; but while in Turtles the second vertebra fits with its head into the pit in the middle of the condylus, in the Saurians and Ophidians, on the contrary, it rides upon a roundish excavation on the upper side of the condylus. Again, the Crocodiles differ from the three other orders of Reptiles by having their round condylus formed only from the os basilare.

There are nine vertebræ of the neck, (not eight as is generally stated,) the second, the so-called odontoid process of the epistropheus, very clearly showing, in these Reptiles, its right to be considered as a distinct vertebra, as it remains separated from the epistropheus through life. There are no transverse processes in any vertebra of the neck. The upper arches are always soldered to the bodies of the vertebræ by sutures. The articulation of these vertebræ to each other is entirely peculiar to Turtles, there being some convex-concave, some concave-convex, one biconcave, (usually the eighth,) and one biconvex, (usually the fifth.) This configuration of the vertebræ gives fixity to certain bendings of the neck, thus depriving it of that flexibility which is characteristic of the neck of the Birds, while it is, at the same time, much more movable than the neck of any other order of Reptiles, or that of the lower Vertebrates.

[1] In Hydromedusa, nasal bones have been discovered by W. Peters, (Observationes ad anatomiam Cheloniorum, Berol., 1838.) Whether this character is common to all Hydraspides, remains to be seen.

The vertebræ of the chest and abdomen are, as in Birds, soldered together into one inflexible and more or less convex arch, though there are still thin cartilaginous cushions between them. That connection is chiefly effected by the spinal processes, which grow continuously, without an intervening suture, into the ossified shield formed in the corium all over the back, thus forming a kind of framework for that superimposed roof.

The ribs are fixed to the places where the vertebræ meet, but the vertebræ do not send out peculiar processes for their support. They are strongest in those Turtles in which the ossifications of the corium are least extensive, namely, in the Trionychidæ, Sphargididæ, and Chelonioidæ; weaker in the Chelydroidæ and Emydoidæ; weakest, and indeed often disappearing entirely, in the land Turtles.

The sternum consists of nine bones, four in pairs, one odd,[1] all of which are true bones. Their relation to each other in size and connection varies greatly in different families. While in the land Turtles and Emydoidæ they form one solid, continuous, broad shield, covering the whole chest and the abdominal region from below, they are much less developed in some of the Cinosternoidæ, (Ozotheca, for instance,) and least in the Trionychidæ, Chelonioidæ, and Sphargididæ. In all the three latter families, the bones of the sternum are very narrow, meeting each other by slender processes, leaving much room between them, which is filled out by the corium, thus forming a flat, elastic sternum.[2] The sternum is jointed to the ribs by means of a bony bridge, which may be compared to the cartilaginous or bony bridge of other vertebrates, while the so-called marginal bones are mere ossifications of the skin.

The vertebræ of the tail are very movable, convex behind, concave before. No spinal processes either above or below.

The locomotion in Turtles is entirely restricted to the four legs. The bones which are subservient to locomotion, appear entirely peculiar to this order of Reptiles, as far as their form and connection with each other, as well as their position with reference to the other parts of the skeleton, are concerned.

The shoulder apparatus no longer rests upon the ribs as in the other Vertebrata, but lies in advance of the ribs, and is more or less withdrawn under them. The whole construction of these Reptiles shows the intention to cover all soft parts by a hard shield. This being the case, there is no room for a movable apparatus upon the ribs. As the shoulder apparatus with the humerus, so also is the

[1] This odd bone is wanting in the full-grown Cinosternoidæ.

[2] It is for this reason, perhaps, that we do not find, in these three families, the sternum of the males scooped out, (to facilitate copulation,) as we find it generally, though not always, in land and marsh Turtles. In Sphargididæ the sternum is reduced to a bony ring, consisting of slender pieces, and the disc inclosed by it is mere corium. The odd bone seems to be wanting.

pelvis with the femur, withdrawn under that large bony roof, though the ribs do not extend over the pelvis as they do really over the whole shoulder apparatus. As we have already seen, in the preceding section, that this bony roof is formed of the ossification of the skin, it is plain that the position of the four limbs, below its spreading margins, does not alter their homologies, and that on the whole the locomotive members occupy here, as in all quadrupeds, a normal position upon the sides of the backbone, and that they are as usual protected by the general covering of the body, only that here this outer envelope is ossified. It follows, therefore, that Testudinata cannot form a class by themselves. The shoulder is composed of three narrow bones, rather long and straight, meeting in one point, and forming at their junction the cavitas glenoidalis for the humerus. Two of these bones, soldered together at right angles[1] as one bone, represent, the upper one, the scapula, the lower, the furcula of the Birds;[2] the third bone, running backwards, answers to that bone in Birds which, coming from the scapula, rests in a deep, transverse socket of the sternum. Merely to use names already adopted, and without intending to homologize these bones beyond the limits here alluded to, we shall call the first, scapula, the second, acromion, and the third, coracoid process. The scapula, a long, cylindrical bone, is attached by a ligament to the dorsal column just before the first (rudimentary) rib; the acromion, a shorter, somewhat flattened bone, is attached to the sternum by syndesmose just before the odd bone. The coracoid process runs backward and hangs free between its muscles; its broad, flattened posterior end, and the end of the acromion, are connected by a strong ligament. This coracoid corresponds in its form and in its relations to the other bones of the shoulder apparatus, though not in its attachment to the coracoid of the Saurians, the Crocodiles, and the Birds, in all of which its

[1] There is only one exception known to this general rule. In a skeleton of a North American Emys, in the Anatomical Museum of Berlin, there is on one side of the animal a suture between these two bones. See STANNIUS, Handbuch der Zootomie, I., 2d edit., p. 75, note.

[2] There has been much diversity of opinion about the homology of the three bones of the shoulder apparatus of the Turtles, and the two or three bones which we find in their place in other Vertebrata. Bojanus, in his great work, Anatome Testudinis Europææ, Vilnæ, 1819, at first mistook the coracoid for the scapula, and called clavicula the scapula, together with the acromion (see Pl. viii., O and N); but he soon afterwards corrected himself in the Isis. Cuvier, and most anatomists now living, Stannius, among them, in the second edition of his Handbook, have named these bones as we do, while in his first edition, p. 139, Stannius called the acromion, clavicula. Duméril and Bibron (Erpétologie generale, I., p. 382) call the coracoid, clavicula. We see here that for each bone nearly all possible homologies have been supported by some writer or other. This seems to show that there are limits to homologizing. Though we are persuaded that these bones of the Turtles are homologous to those of the Birds in the manner in which we have referred them, one to the other; yet we do not dare to go farther, and homologize them at the same time with the bones of the shoulder in Mammalia, and still less with the thoracic arch of Fishes.

lower end rests in a socket, in the foremost part of the sternum; but in Turtles the whole shoulder apparatus being drawn inwards and backwards, this bone had to be removed from the sternum, and lies free in the muscles.

The humerus is short, crooked, and turned inwards in such a way that it moves inwards in one plane with the scapula and coracoid. The forearm is articulated upon the large lower epiphysis of the humerus, but its position is peculiar to the Turtles, its transverse diameter standing vertically. This is effected by an overlying of the fibula upon the radius. In the structure of the hand, we find again, in the same manner as in the forearm, the transverse diameter standing vertically, the ulnar side above, the radial side below. This singular conformation of the shoulder, the arm, the forearm, and the hand, makes it possible for the fore leg to be drawn back under the upper shield by the bending of all the joints in the plane of the scapula. This motion is more or less extensive in different families, according to the degree of expansion of the carapace.

The conformation of the hand varies much in different families, according to its function as a paddle, as a fin, or as a pillar.[1]

The pelvis is much easier to understand than the shoulder. It is formed, on each side, by three permanently distinct bones, meeting in the condyloid cavity. Two pairs of these bones are flat and more or less horizontal, and rest upon the sternum, to which they are more or less closely attached. The larger pair, the ossa pubis, leans forwards, the smaller pair, the ossa ischii, backwards. The bones of each pair unite respectively with one another in the middle, in a median line, while the two bones of the same side, meeting laterally, form the lower part of the cavity for the femur. The upper part of this cavity is formed by the third pair of the pelvic bones, the ossa ilii; these are smaller cylindrical bones, much enlarged at both ends, running upwards and backwards, and meeting with the long transverse processes of the sacrum.

The bones of the hind leg agree generally with those of the fore leg, though the femur is straighter than the humerus. There are, however, great differences in different families, in respect to the relative size of the two pairs of the legs. These differences are so strongly marked between the marine Testudinata on one side, and the fluviatile and terrestrial types of the order on the other side, that they cannot be considered as family characters, but rather point out a natural subdivision of the whole group, already hinted at above,[2] and to which I shall again call attention hereafter.

[1] See the Family Characters, below, Chap. 2.

[2] See, above, Sect. 2, p. 241–249.

SECTION VII.

MUSCLES.

The ordinal characters of the Turtles, as far as the muscles[1] are concerned, are particularly obvious in the muscles of the neck and in those of the region of the trunk. That bulk of muscles which in Ophidians and Saurians lies above and below the vertebral column and the ribs has almost entirely disappeared, owing to the immovability of the trunk.[2] There exist only two muscles along the back of the Turtle, and even these disappear in that family, which is characteristic of the highest development of the order, in the land Turtles. These muscles are, a musculus longissimus dorsi and a M. retrahens capitis collique, both originating from the dorsal column or its neighborhood, and attached to the neck or to the head; so that, properly speaking, even these are more muscles of the neck than of the trunk.

The musculus longissimus dorsi[3] runs along the back on both sides of the vertebræ, between the ossified corium and the ribs. It originates from about the eighth or ninth to the fourth or third rib and the dorsal shield of that neighborhood, and is attached to the last or to the two last vertebræ of the neck. It is very large and powerful in the family of the Snapping-Turtles, (Chelydroidæ,) the arches through which it passes being here high and broad. This passage is much narrower in the family of the Emydoidæ, and the muscle also much weaker; in Cistudo virginea, the highest of the Emydoidæ and the nearest to the land Turtles, we see it developed only in the anterior part of the trunk, until in the land Turtles it disappears entirely. Even the arches through which it passes in other Turtles disappear in consequence of the resorption of the ribs which takes

[1] For further details respecting the muscular system, see BOJANUS, Anatome Testudinis Europææ, Vilnæ, 1819–21, 1st vol. For a comprehensive abstract of what is now known respecting the muscular apparatus of all Turtles, see the valuable work of STANNIUS, Zootomie der Wirbelthiere, 2d edit., Berlin, 1856.

[2] A distinct muscular layer above the ribs, and distinct musculi intercostales, are only to be found in very young Turtles, in embryos, or in specimens recently hatched. I have seen these muscles most distinctly in the young Chelydra serpentina and in Trionyx ferox. See also RATHKE, (R.,) Ueber die Entwickelung der Schildkröten, p. 155.

[3] In Emys serrata, Lesueurii, and geographica, this muscle is much smaller than in E. Europæa, as it has been described by Bojanus. In Emys concentrica, it is the same as in the European species. But in Chelydra serpentina this muscle is very powerful, and the arches, near the dorsal column, through which it passes, are very large and high. In Chelonia Mydas, it is small. In Cistudo, we find it only in the anterior part of the dorsal column, and in Testudo there is no trace of it.

place in this family in proportion as the ossification of the skin advances. This is the muscle above the ribs.

The second muscle, the M. retrahens capitis collique, is below the ribs. This muscle is peculiar to the Turtles, the conditions of its existence being a solid trunk and a very movable neck. It originates from the bodies of all or most vertebræ of the trunk, and is attached to the articulating processes of the vertebræ of the neck and to the occiput. In some Turtles, it would be better to consider it as divided into two distinct muscles,[1] as its action is not always simultaneous.

[1] Bojanus has described these muscles as one, in accordance with the subject of his investigations, the Emys europæa, in which the division into two muscles is much less marked than in many other genera, Ozotheca, for instance. In Emys serrata, we find it as in Emys europæa. In Emys concentrica, the muscle is one, originating from the eighth to the sixth dorsal vertebra, and attached from the sixth to the fourth neck vertebra, and with a long tendon to the occiput. In Emys geographica and Lesueurii, it is the same. In Cistudo virginea, it arises from between the ribs near the tenth to the second dorsal vertebra to the seventh and fifth neck vertebræ and the occiput. In Ozotheca odorata, we see distinctly two muscles. One of them, the M. retrahens colli inferioris, originates on each side of the dorsal column from the base of the third to the fifth rib, and is attached laterally to the penultimate (eighth) vertebra of the neck. This muscle draws the lowest part of the neck backwards and upwards. The other, the M. retrahens capitis collique superioris, originating from the bases of the fifth to the seventh ribs, is attached with one tendon to the uppermost part of the sixth neck vertebra, with another to the occiput. This muscle draws the uppermost part of the neck and the head backwards. When Ozotheca retracts its large head, which it does faster than any other Turtle, both muscles first operate simultaneously, but soon the short M. retrahens colli inferioris is entirely contracted, while the other is drawing further. Beyond these two muscles, we find in this genus a third muscle much developed, which serves the same purpose. The M. lateralis retrahens ultimæ vertebræ colli, originating from the base of the second rib and the space between this and the third, and attached to the uppermost lateral part of the last (ninth) neck vertebra. This muscle is strong also in Cistudo virginea, where, however, it originates only from the base of the second rib. In our Green Turtle, (Chelonia Mydas,) we find a distinct though weak M. retrahens colli inferioris from the first dorsal to the last neck vertebra, while the M. retrahens capitis collique superioris is entirely wanting. But at the same time, it is well known, that in this family the power of retracting the head and the extremities under the shield is very much reduced, indeed, almost entirely wanting. On the contrary, in Testudo tabulata these muscles are very strong. The M. retrahens capitis collique superioris originates from the seventh dorsal to the first sacral vertebra, and is attached from the third to the fifth neck vertebra and the occiput; the M. retrahens colli inferioris, from the first to the sixth dorsal vertebra, and from the sixth to the ninth neck vertebra. Thus, both these muscles occupy the dorsal column from the head to the sacrum. In these land Turtles we observe, indeed, the other extreme of what we have noticed in the sea Turtles, as in them all structural elements are employed for the purpose of covering all the soft parts by a thick, large shield, under which they are retracted. In Chelydra serpentina, we may consider these muscles as one, originating from near the tenth to the fourth dorsal vertebra, (rather from the bases of the ribs in this region,) and attached to the eighth and seventh neck vertebræ, and with a long tendon to the occiput. In this family, however, this muscle is not developed in the same degree as the remaining muscular system, and particularly that of the legs and tail, which is truly extraordinary, and aids in the peculiar darting motions of the body.

The first of these is a very long muscle, originating from the posterior vertebra of the trunk, and attached to the foremost neck vertebra and the head. Its function is to draw back the head and the uppermost part of the neck, so that we may call it musculus retrahens capitis collique superioris. The second muscle is much shorter, originating from the anterior vertebræ of the trunk, and attached to the lower part of the neck. It lies below the first, and its function is to draw the lower part of the neck backwards. We may call this muscle M. retrahens colli inferioris. The form into which the neck is thus contracted is that of an S in a vertical plane. I regret deeply that I have not had an opportunity of examining the arrangement of the muscles of those Turtles which bend the neck sideways and fold it under the margin of the shield, as do the Chelyoidæ and Hydraspides.

Considering now the cervical muscles proper, we find a system of shorter muscles largely developed, running from one vertebra to the next or to the next but one. These muscles are particularly subservient to stretching the neck into a straight line, when it has been bent by the muscles described above, and thus to dart it forwards, as all Turtles do more or less rapidly. This action is, however, peculiar and very quick and powerful in the families of Chelydroidæ and Cinosternoidæ.

The posterior part of the dorsal column, with its free vertebræ between the sacrum, the anus, and the tail, is also provided, like the free movable neck, with a well developed muscular apparatus, which is particularly powerful in Chelydra. The muscles which move this part originate from the three pairs of pelvic bones.

The muscles of the shoulder and of the pelvis, which are all inside the bony box, are very difficult to homologize with those which we find in other Reptiles or in other Vertebrata. Two pairs of muscles, originating from the hind part of the plastron and attached to the ossa ischii and pubis, draw the pelvis, the first backwards, the second forwards. Stannius mentions traces of Musculi recti in some Turtles, originating from the anterior ventral part of the pelvis. Musculi obliqui externi and interni are obvious in almost all Turtles. The obliqui externi are particularly developed. Originating from the inside of the marginal bones of the dermal shield, they are attached to the os pubis.

The muscles for the shoulder are not much developed in comparison with those of the Saurians or Birds, in which the shoulder lies free on the outside of the ribs. There is one muscle in Turtles drawing the scapula forward, the M. scalenus or levator scapulæ of Bojanus, originating from the lower part of the vertebræ of the neck and attached to the acromion; and another, originating from that large crosspiece mentioned above, p. 265, (which may be looked upon as a processus transversus, or as a first rudimentary rib,) and from the dorsal shield in its neighborhood, going to the scapula and drawing it backwards. This muscle is the M. subclavius or retractor scapulæ of Bojanus. A third muscle is extended between the tongue-bone and the coracoid, the M. coracohyoideus. Besides this muscle, which originates from the lower side of the bony framework of the tongue-bone, we find for the tongue two other pairs of muscles, the musculi hyothyreoidei and the musculi cricoarytænoidei.

The muscular apparatus of the extremities is remarkable for its similarity to that of Mammalia.[1] In place of the M. pectoralis major, we find two muscles, one originating from the middle part of the sternum and attached to the tuberosity of the humerus, whence it spreads downwards over the arm and the forearm, and another, much weaker, arising from the anterior part of the sternum and attached to the same internal tuberosity. The deltoid muscle originates from the end of the acromion and goes to the same tubercle. The muscles arising from the scapula, the M. subscapularis and the M. teres, are both attached to or near the tuberculum externum. A muscle corresponding to the M. latissimus dorsi, arising from the exterior lateral part of the dorsal shield, is attached to a little cavity inside of the tuberculum externum. The M. coracobrachialis, arising from the coracoid and attached to the tuberculum externum of the humerus, is simple in the family of Emydoidæ, and double, as in Mammalia, in the Trionychidæ. The muscles of the forearm, and those of the hand and fingers, are essentially identical with those of the Saurians; the degree of development of the muscular apparatus of the hand and fingers varies much, however, in different families. They are much less developed in the sea and land Turtles than in the webfooted Emydoidæ, Cinosternoidæ, Chelydroidæ, and Trionychidæ. The characteristic muscles of the hind extremities are the following: two musculi glutæi, (a major and a minor,) originating from the os ilii and from the seventh rib. Forming at first one muscle, they are soon divided into two branches, one of which is attached to the trochanter, the other to the femur itself. The M. biceps, originating from the os ilii, is inserted upon the fibula. The M. psoas, originating from the last vertebra of the back, before the sacrum, is attached to the upper part of the femur. The Musculi adductores femoris originate, one from the symphysis ischiadica, another from the os pubis, and a third from the membrana obturatoria and from the anterior margin of the os ischii.

[1] Its development, however, is very different in different families. The fore legs and the hind legs have an equally strong muscular apparatus in land Turtles, where the whole body stands in equilibrium; while in sea Turtles, in which the fore legs are the chief locomotive organs while the hind legs serve almost only as rudders, the fore legs have a much larger muscular development.

SECTION VIII.

NERVOUS SYSTEM.

With reference to the brain, we may single out as characteristic of the Testudinata the well developed hollow hemispheres, which are larger in proportion than in other Reptiles, especially when compared to the lobi optici. Their surface is generally smooth, but in some it is provided with a longitudinal fold. Their cavities are continued into the hollow roots of the olfactory nerves. The cerebellum is relatively larger than in Ophidians and Saurians, yet smaller than in Crocodiles. A longitudinal furrow divides it into halves. Between the two hollow lobi optici and the hemispheres, there are two lobi ventriculi tertii, which give rise to the optic nerves. Behind the large cerebellum follows a large vascular body, (plexus chorioideus,) which lies upon the sinus medullæ ablongatæ.[1]

In relation to the nerves that originate from the brain and the medulla ablongata, we notice that, as in Ophidians and Saurians, the nervus hypoglossus receives roots from the spinal marrow, which is not the case in Crocodiles. As in Saurians and Ophidians, the nervus vagus and the glossopharyngeus have always each a root for itself, and, as in Saurians, each also a distinct passage through the os occipitale laterale; while in Ophidians there is only one passage, and in Crocodiles, with some exceptions, only one common root for both those nerves, which thus form also only one common ganglion. As in all Reptiles, the largest nerve is the nervus trigeminus; it is larger even than the nervus vagus, though this latter is more developed in Turtles than in other Reptiles.

The spinal marrow is rather thin along the middle of the body; and the nerves which originate in this region are very small, as there is not much room for their function, in consequence of the immovability of that part of the trunk which corresponds to the shield, and which moreover is covered by a thick, hard, horny roof. So much the larger, however, appear the two swellings of the spinal marrow in the shoulder and pelvis region, where the legs, which in this order of Reptiles have to support and to move the whole body, are to be provided with nerves. Thus the size of these swellings, when compared with the general diameter of the spinal marrow, is characteristic of the Testudinata, and more resembles that of

[1] For the differences of the brain in different families, see below under the head of The Family Characters. A beautiful illustration of the brain and the whole nervous system of the European Emys has been given by Bojanus, in his Anatome Testudinis Europææ, Pl. xxi.–xxiii.

Birds than of other Reptiles, in which latter the organs of locomotion are never confined to the legs alone. See above, p. 253.

The characteristic features of the N. sympathicus[1] are only to be appreciated by a minute comparison of all its original roots, anastomoses, ganglia, etc., with those of Crocodiles, Lizards, and Snakes. But, though there are many differences in its conformation in these different orders of Reptiles, we do not deem it necessary or useful to enter into the details of such a comparison; in the first place, because only some two or three species of Turtles have as yet been investigated with special reference to that nerve, so that there would be danger of confounding ordinal with family or even generic characters; and in the second place, because the differences which we have noticed do not show an intimate connection with the whole nature of the Turtles, in contradistinction to other Reptiles. It is, moreover, proper that in Comparative Zoölogy we should introduce only such anatomical characters as are understood in their connection with the whole nature of the animals under consideration. Other anatomical details would be useless for the zoölogist.

SECTION IX.

ORGANS OF SENSES.

The Ear. There is no movable external ear as in the Crocodiles; but in all Testudinata we find a cavitas tympani and a membrana tympani, which are wanting

[1] The N. sympathicus begins in Turtles as plexus sphenoideus, and is connected with the second branch of the N. trigeminus. It runs as a simple trunk backwards, gives branches to the nose, and receives branches from the N. abducens facialis; then after passing through the os petrosum as N. Vidianus it receives branches from the N. facialis and glossopharyngeus, then from the N. vagus and hypoglossus, and then runs as one superficial stem along the neck to the thorax, connected by branches with the nerves of the neck. Then taking up branches of the vagus, it forms the ganglion thoracicum primum, which sends its threads to the plexus cardiacus and pulmonalis. Then the string forms several swellings, connected with the plexus brachialis, forming several loops which unite again into ganglia and communicate with the anterior branches of the spinal nerves. Then after giving branches which go to the intercostal nerves, it forms again two plexus, the first sending branches to the stomach, and accompanying the arteria cœliaca; from the second plexus originate branches for the intestines, and others for the kidneys and the generative organs. See STANNIUS, Lehrbuch der Vergleichenden Anatomie der Wirbelthiere. Berlin, 1846, p. 192–93; BOJANUS, Anatome Testudinis Europææ, Pl. xxii. and xxiii.; and SWAN, Illustrations of the Comparative Anatomy of the Nervous System, London, 1841, Pl. xv. and xvi.

in Saurians.[1] The helix is a simple, round, membranous sac, with a closed fenestra rotunda, and a communication with the saccus vestibuli by means of a membranous canal. A very long columella is attached to the fenestra ovalis, which itself is closed by an opercle. The cavitas tympani is divided into two parts by a bony septum. The tunica tympani is only attached to the os quadratum. Between the two lamellæ of this membrane lies a cartilaginous plate, into which the columella is inserted.

The Eye. This organ is larger in proportion and more movable in Turtles than in other Reptiles.[2] We find in the constitution of this organ a great similarity with Birds. Not only are the protecting membranes of the eyeball in Turtles and Lizards, in contradistinction to Snakes, very much as in Birds, there being two eyelids and a membrana nictitans, but we find in Turtles also the same bony framework in the cornea as in Birds. This bony ring has been erroneously ascribed also to Crocodiles.[3] It does not exist either in these, or in Ophidians, or in Saurians, but singularly enough we find it again in all those huge Reptiles of past ages known as Plesiosauri and Ichthyosauri. The iris of Turtles is always colored, generally dark, but in some red, or even milk-white. We see, however, that this color varies much in one and the same species, as, for instance, in Cistudo virginea, in Ptychemys concinna, etc. The form of the pupil, which is vertical and elliptical in many Snakes and Saurians and in all Crocodiles, is round in all Turtles, as it is in Birds. There is, however, no pecten in the vitreous body, as in all Birds and in many Saurians; the vitreous body itself is very large. In the orbita we find two well developed glands, namely, a lachrymal gland above the bulbus, and another, a Harderian gland, behind and inside.

The Nose. While the sense of seeing, and particularly that of hearing is highly developed in Turtles, the sense of smelling is much less so; and while the former two senses exhibit in them a degree of perfection which we find elsewhere only in warm-blooded animals, Turtles do not at all stand above the level of other Reptiles with respect to the latter sense. In explanation of this we may perhaps say that the slow rhythm of the respiration, which is common to all four orders of Reptiles, does not facilitate the admission of odoriferous materials into the nose, and that it is for this reason that we find the nerves and bones of this organ

[1] In Duméril et Bibron, Erpétologie générale, vol. i., p. 399, this membrane is erroneously said not to exist in Turtles.

[2] There is one single exception to this statement; in the South-American Matamata, (Chelys fimbriata,) the eyes are remarkably small. This Turtle, however, so peculiar also in other respects, and particularly in the structure of its head, forms unquestionably a family for itself.

[3] Already Sœmmering, and later, Rymer Jones, in Todd's Encyclopædia of Anatomy and Physiology, vol. iv., p. 314, have made this statement, which we must deny, in accordance with the observations of Tiedemann, Stannius, and our own.

so little developed. The cavity of the nose is wide, but short. There are no sinus frontales, nor lamina cribrosa, nor bony concha, nor even nasal bones.[1] The concha is cartilaginous. The nervus olfactorius is characterized by two tubercles at its base, just in advance of the hemispheres; it has, in this respect, a strange similarity with that of Frogs. The nostrils are always situated in the topmost part of the snout; they seem particularly subservient to breathing, in water Turtles at least. Thus I have frequently seen Trionyx ferox lying for hours in shallow water, buried in mud, and stretching only, from time to time, the nostrils above the level of the water to breathe. The South-American Matamata is said to await its prey in a similar situation, hid among the leaves of water plants, exhibiting nothing above the water but the nostrils, which are elongated and tube-like, as in Trionychidæ. The marine Turtles also come from time to time to the surface for the sake of breathing.

The Tongue and Mouth. In all Ophidians and Saurians, as in most Birds, the tongue is only an organ of touch; in most of these animals it is long, slender, covered with horn, and may be more or less protruded from the mouth for that object. This is by no means so with the tongue of Turtles. It is broad, thick, fleshy, generally folded, mucous, and in one family (the land Turtles) even thickly provided with papillæ, like the tongue of a parrot. Turtles chew their food, particularly the herbivorous land Turtles, while other Reptiles swallow it without chewing. Thus the organ of taste is very much developed. Not only the tongue, but in some, as for instance in Trionyx, the whole pharynx is beautifully fringed with fine, tree-like, branching papillæ,[2] while in Chelonioidæ we find long, strong, and hard papillæ, extending even into the œsophagus. The papillæ of the latter seem, however, from their hardness, more subservient to the motion of the food than to tasting. But tasting is by no means the only function of the tongue. Filling out the whole cavity of the mouth, it has also another function in the process of breathing, as it has also in Frogs, for Turtles swallow the air they breathe. (See, below, p. 281.) In all Turtles we find salivary glands.

Organ of Touch. There is no special organ for this sense to be found in Turtles.

[1] Comp. p. 30, respecting Hydromedusa, which forms an exception, as it has nasal bones.

[2] Comp. Dr. A. Sager's Notes on the Anatomy of the Gymnopus spinifer of Duméril and Bibron.

SECTION X.

EATING, DRINKING, AND DIGESTIVE APPARATUS.

In describing the skin, we have already mentioned the characteristic horny sheath of the jaws, which forms a bill such as we find only in Birds besides. The upper jaw always includes the lower, as it reaches beyond this. Generally, the horny sheath which covers the jaws runs more or less inwards into the mouth; in the Chelonioidæ, it forms even several ridges parallel to the margin of the jaw, evidently for crushing and breaking the thick sea-weeds, upon which they feed. As all other Reptiles have true teeth and no horny cover whatsoever on the maxillar bones, this sheath is peculiar to the order of Testudinata;[1] and while all other Reptiles use their jaws merely for seizing their food, Turtles, on the contrary, chew it. This is particularly the case with the herbivorous families, Chelonia and Testudo. A much more extensive use of the tongue is connected with the act of chewing, as long as the food is in the mouth, than we observe in other Reptiles. Thus the fleshy tongue of the Turtles serves three different purposes: first, in tasting, (see p. 277,) then in the act of respiration, (see p. 281,) and thirdly, in managing the food as long as it is in the mouth; that is, for bringing it into the right position between the sharp scissors formed by the bill, and for moving it into the pharynx and œsophagus when it is sufficiently divided. The last two uses of the tongue are the more interesting, as we do not meet them again, to this extent, except in Mammalia. The tractus intestinalis has generally thick walls. The œsophagus of the family of Chelonidæ is provided with long, hard papillæ. The stomach lies always transversely, crossing the body from the left to the right. The length of the whole intestine, in comparison with the length of the trunk of the animal, varies very much in different families, being longer in the herbivorous, and shorter in the carnivorous Turtles, just as among Mammalia and Birds. The relative length of the different parts of the intestine, compared with each other, varies still more; the rectum being very short in Emydoidæ, Cinoster-

[1] Yet the order of Turtles is not the first among Vertebrates, in which we find the jaws transformed into a bill. We find already something similar among the Fishes, in the so-called Parrot Fishes, (Scarus,) and again among Amphibia, in the larvæ of the Batrachia anura. I may add, however, that after removing the horny sheath, we find, along the dental ridges of the jaws, in the young Trionyx and Chelydra, a regular series of holes for nerves, which are evidently homologous to the alveolæ of the teeth in other Reptiles. These holes contain, however, no rudimentary teeth, as are found in the jaws of Whales.

noidæ, Chelydroidæ, and Trionychidæ, and very long in land Turtles and in Chelonioidæ. Our observations show this variation to extend to such a degree that we are unable to obtain from this part of the organization of the Testudinata an ordinal character, in contradistinction from the other Reptiles, as the following table satisfactorily proves.[1]

Family.	Species.	Total weight of the body in ounces.	Length of the Carapace in inches.	Total length of the digestive duct.	Œsophagus.	Stomach.	Small Intestine.	Cæcum.	Large Intestine.	Cloaca.
Land Turtles, (herbivorous.)	Testudo polyphemus, fem.	100	$10\frac{1}{2}$	$82\frac{1}{2}$	$4\frac{3}{4}$	$8\frac{1}{4}$	$21\frac{1}{2}$	$\frac{5}{8}$	$44\frac{1}{2}$	$8\frac{1}{2}$
Land Emydoidæ, (omnivorous.)	Cistudo, triunguis, (3 toed Box-turtle,) fem.	15	$5\frac{1}{2}$	31	3	$3\frac{1}{2}$	$19\frac{3}{8}$	$\frac{3}{8}$	$5\frac{1}{8}$	
Water Emydoidæ, (omnivorous.)	Emys rugosa, (rubriventris,) fem.	62	11	99	5	$7\frac{1}{8}$	$70\frac{3}{8}$	1	13	$3\frac{1}{2}$
Cinosternoidæ, (carnivorous.)	Cinosternon pennsylvanicum, fem.	$8\frac{1}{2}$	$4\frac{1}{2}$	$24\frac{1}{4}$	$3\frac{3}{8}$	$2\frac{1}{8}$	$16\frac{1}{2}$	0	$2\frac{1}{4}$	
Chelydroidæ, (carnivorous.)	Chelydra serpentina, male.	65	$10\frac{1}{2}$	$80\frac{1}{2}$	10	$7\frac{1}{4}$	$48\frac{3}{4}$	0	$11\frac{1}{2}$	$3\frac{1}{2}$
Trionychidæ, (carnivorous.)	Trionyx ferox, fem.	76	13	$58\frac{1}{2}$	6	6	35	0	6	$5\frac{1}{2}$
Chelonioidæ,[2] (herbivorous.)	Chelonia Caouana.	77		102						

[1] These measurements may be of interest, as they were made upon fresh specimens. The numbers, which express the length of the parts in the table, indicate American inches, twelve of which make one foot; the weight of the body is given in officinal ounces, twelve of which make a pound, and one of which is equal to 480 grains. In this table, which explains itself, we will only point out Cistudo, which, upon a superficial examination of its outlines, would seem to belong to the Testudinina, (land Turtles,) and which, by the proportions of the different parts of its intestines, is in reality an Emydian, as it will be shown below from a critical examination of its forms. See The Family Characters, below.

[2] This last measure, respecting Chelonia Caouana, is borrowed from the valuable Chemical and Physiological Investigations by Joseph Jones, published in the Smithsonian Contributions to Knowledge, vol. viii., 1856, where the student will find many interesting data relating to the digestion of Turtles in comparison with other cold blooded, and with warm blooded animals.

The whole tract of the alimentary canal is provided with folds, between which there are everywhere crypts from the stomach to the anus. The cœcum is small, or wanting. A large, broad liver, continuous from one side of the body to the other, by means of a bridge, receives the heart in front between its two halves. A large gall-bladder is imbedded on the right side. The spleen and the pancreas are never wanting; the spleen is generally attached to the pancreas, and this to the duodenum. The spleen is an ovoid, or globular, solid body, while the pancreas is more or less divided into lobes, often broadly and thinly scattered, particularly in the herbivorous Turtles, and, on the whole, of a very irregular shape. As among Mammalia, so among Turtles, the pancreas is generally much larger in the carnivorous families than in the herbivorous, having, for instance, in the herbivorous Testudo polyphemus only about $\frac{1}{3000}$ the weight of the body, while in Emys serrata, which feeds upon fishes, mollusks, and worms, etc., about $\frac{1}{1200}$, and in Chelonura serpentina, which is entirely carnivorous, even $\frac{1}{680}$. But, as a strange exception, we see in the herbivorous Chelonia Caouana the number $\frac{1}{618}$.[1] All Turtles digest rather slowly, particularly the herbivorous land Turtles, which keep always a store of half-digested vegetables in their enormously large intestine. Turtles stand hunger for several months; Emyds, if they are provided with water, for more than a year. All Turtles which we had an opportunity to observe, when drinking, held the head under the level of the water, and evidently swallowed the water. The Galapagos land Turtles, (Testudo indica,) however, are said to drink like most Birds, by taking a mouth full of water, and then holding up the head and neck vertically, letting the water run down through the œsophagus. Turtles, (particularly the land and fresh-water Turtles,) like Frogs, usually carry with themselves a quantity of water in the cloaca. According to recent observations of Professor J. Wyman, this water is taken up through the anus.

[1] See Jos. Jones, l. c., p. 107, where a list is given containing the weight of the pancreas in proportion to the body for several Fishes, Amphibians, Reptiles, and Mammalia. For the Loggerhead-Turtle, (Chelonia Caouana,) which J. Jones has numbered among the carnivorous Reptiles, we have to remark, that as far as we know it feeds, like the other Chelonioidæ, upon sea-weed. If this be true, the law given by J. Jones, in relation to the proportionate size of the pancreas, (l. c., p. 108,) is evidently not without exceptions, and it shows also how careful we must be in drawing such broad conclusions.

SECTION XI.

RESPIRATION.

Here, again, we meet with a very striking ordinal character. The Turtles swallow the air they breathe.[1] The breast-box, which includes the lungs, being immovable, a respiration like that of the other Reptiles, the Birds, and Mammalia, performed by the expansion and compression of the breast-box, and consequently of the lungs, is impossible. Owing to the peculiar structure of their trunk, breathing is, therefore, only possible for Turtles by a pressure of the air from the mouth down into the lungs; but, though we are persuaded that this swallowing of the air constitutes the main act in the process of breathing, still we are inclined to believe, against the opinion of other anatomists, that the diaphragm, which in Turtles is very much developed, and attached to the lungs, takes also its part in that act.[2] Moreover, the muscles of the shoulder and of the pelvic region may assist in that operation, either by immediately compressing the lungs, which generally extend in Turtles from one end of the trunk to the other, or by pressing the bowels against them.

The act of swallowing the air is chiefly performed by the apparatus of the tongue-bone, and the tongue itself, which, by its large size, facilitates the operation. Being drawn backwards and upwards, this organ shuts up the choannæ, and at the same time opens the slit of the windpipe, situated just at its base, thus giving to the air a passage into the windpipe, and at the same time preventing its entrance through the choannæ into the nose. In this way, the tongue takes the place, in a certain sense, of the velum palatinum of the higher Vertebrata, which is wanting in Turtles. After the air has passed into the windpipe, the tongue is drawn forwards, and thus the longitudinal glottis is again closed, while now the choannæ are again opened to a free communication with the cavity of the mouth.[3]

[1] We find the same mode of breathing in the class of Batrachians; but for an entirely different reason, namely, on account of the absence of ribs.

[2] The existence of a diaphragm is erroneously denied to Turtles by Duméril and Bibron, Erpétologie générale, I., p. 175. This work, however, worked out as it seems almost entirely by Bibron, is to this day the best illustration of the Zoölogy of Turtles, as it also is of the Saurians and Frogs, while the part relating to Ophidians, completed after the early death of that able herpetologist, Bibron, contains the most superficial descriptions of genera and species.

[3] In Amphibia, this process is similar, though not the same. It is easy to observe, that in this class the eye-bulbus is often active in swallowing the air; these large balls, when pressing downwards, narrow the cavity of the mouth, and the air moves

The trachea is generally rather short, divided near the base of the neck into two large bronchi, one of which is often so curved as to form a large arch. The lungs are very voluminous; more so in land than in water Turtles. This difference alone, in the size of this organ, accounts almost entirely, both for the high arched body of the true land Turtles which never go into water, and for the flat trunk of the Trionychidæ and sea Turtles, which hardly ever leave the water, except to lay their eggs. But even in the aquatic Turtles, the capacity of expansion of the lungs is great enough to allow them to remain for half an hour or more under the water, as I have had ample opportunities of observing in Trionyx, though it must not be forgotten, that in the family of Trionychidæ, the skin being soft and thus more permeable to water, a kind of respiration of the blood may take place through the skin also,[1] as is the case so extensively in Frogs.

The following table shows the capacity of the lungs in those families, of which I was able to obtain fresh specimens at the time. The experiments were made upon the living animal by pumping out the air of the lungs, then pumping in water, then pumping out the water again and measuring its amount in cubic inches. This table shows that aquatic Turtles require much less air in their lungs, in proportion to the weight of the body, than land Turtles.[2] It shows especially, that in mud and soft-shelled Turtles, the lungs being much reduced in size and importance, by far the greater part of the respiration must be performed by the skin of the whole body, which is much thinner in these families than in other Turtles; while, on the contrary, in the true land Turtles and that land Emydian,

backwards. Again, we find in Frogs, at least in some, for instance in the genus Rana, a movable valve, by which it can close or open the nostrils at will; there is nothing of this kind to be found in Turtles.

[1] The beautifully ramified vessels, which are seen through the epidermis upon the entire lower surface of the body of Trionyx, add great weight to this supposition. See below, p. 284.

[2] It is moreover evident that the capacity of the lungs is not a family character, for while the Testudinina (land Turtles) are generally provided with much larger lungs than the Emydoidæ, our table furnishes the unexpected evidence, that in a member of the latter family they are larger still. The capacity of the lungs in Cistudo, for instance, shows clearly its influence upon the form of the body, and it would thus seem that here, at least, form cannot characterize the family. But this very instance proves, on the contrary, the truth of the principle adopted for the limitation of families, as by a thorough examination we find still in the Cistudo the real character of the form of Emyds, in its sharp contradistinction from the Testudo family. See below, The Family Characters of Emydoidæ. Hence it follows, that the mode of life, and, what depends upon it in the organization of the animal, the capacity of the lungs, the length and proportions of the intestine, etc., are generally, though by no means always, common to a family; and that such definite complications of forms as characterize families may be modified according to the different modes of life, without interfering with or changing the ideal combination. This ideal is the conception of the Divine Mind. The conception however is not changed, in the act of being expressed in living realities, but only specified; and this is done in the various members of a family, according to their mode of life, etc.

the Cistudo, the process of respiration is no doubt performed entirely by the lungs. This remarkable difference is not only owing to the greater or less thickness of the epidermis, but particularly to this circumstance, that air does not penetrate a horny epidermis so easily as water. Thus, aquatic animals probably absorb the water through the whole surface of their body, and that water, being impregnated with oxygen, is made subservient to respiration; while, on the contrary, animals living on land are much less capable of breathing through their skin, the air penetrating the epidermis with greater difficulty. This seems to be rendered evident by our table, if we compare Testudo with Trionyx. We suppose the same law may have its application in regard to the respiration of all animals; and that animals living in water generally require a much smaller development of the breathing organs proper than animals living in the atmospheric air.

TABLE,

SHOWING THE CAPACITY OF THE LUNGS COMPARED WITH THE WEIGHT OF THE BODY.

Species.	Mode of Life.	Weight of the Body.	Capacity of the Lungs.	Length of the Carapace.
Testudo polyphemus. (Gopher.) Female.	On dry ground and in sand-holes.	95 Ounces.	35 Cubic In.	10½ Inches.
Cistudo triunguis. (Three Toed Box-Turtle.) Female.	In dry woods, under leaves, etc.	19 "	17¾ "	6¾ "
Ptychemys rugosa. (Emys rubriventris.) (Red Terrapin.) Female.	In water and on land.	62 "	22½ "	11 "
Cinosternon pennsylvanicum. (Mud-Turtle.) Female.	In water and mud.	8 "	½ "	4½ "
Chelydra serpentina. (Snapping-Turtle.) Male.	In water and mud.	65 "	7 "	10 "
Trionyx ferox. (Soft-shelled Turtle.) Female.	In water and mud.	76 "	4½ "	13 "

But there is another interesting circumstance, to which I would allude in this connection. Dr. A. Sager says, that, "arranged along the surface of the tongue of Trionyx and somewhat in rows, as well as on the fauces and about the rima glottidis, and also over the edges of the cornua hyoidea, there exist a great number of delicate fringes, resembling, especially on the hyoid arches, the fimbriated gills of the Menobranchus or the internal gills of a Tadpole."[1] Before reading this paper, we had noticed these organs; but, after seeing this Turtle remaining under water for half an hour without showing the least sign of oppression, it seems plausible to assume that these fringes may be similar to the internal gills of Tadpoles, not only in their shape, but also in their function. There exists, moreover, an extensive network of beautiful vessels, spreading in elegant dendritic ramifications upon the whole lower surface of the Trionychidæ, which can hardly have another function than that of assisting in the process of breathing, as they are too numerous and too large to be considered simply as the nutritive vessels of the skin. This is the more probable, as these vessels are very superficial, and only covered by a very thin epidermis. They are indeed as plainly visible, through the horny layer which protects them, as the vessels of any special external breathing organ, and give to the lower surface of the body, over which they extend, a very ornamental appearance.

Turtles have a voice. Though I have myself made this observation only in a few species, namely, in Emys elegans, serrata, picta, and insculpta, which emit a piping note,[2] and in Chelonia Mydas, whose voice resembles somewhat a quick, low bark. I am inclined to believe that all of them have, more or less, the faculty of emitting distinct sounds. Sphargis has its name even from σφαραγέω, to make a noise. But, whether this name is meant only for that sharp hissing sound which all Turtles produce, when they are excited, or whether it is intended to designate a real voice, I am not able to state, as I have never heard the sounds emitted by Sphargis. However, it is reported of many Turtles, especially of the Chelonioidæ, that they cry aloud when they are seriously wounded.

I have not yet been able to ascertain to what extent the respiration is reduced or interrupted in those Turtles which burrow under the ground during the winter. In the more aquatic species, however, which secrete themselves in the mud, under the surface of the water, the pulmonary respiration is, of course, entirely suspended. The changes, which the other functions undergo in different families during this state of hibernation, have not yet been investigated. It would be easier to make these observations in the Southern States, where the waters remain open all the year round, than in the Northern States, where the ground is covered annually, for several months, by a thick sheet of snow and ice.

[1] Compare Dr. A. Sager's Notes on the Anatomy, etc., quoted above, p. 277.

[2] Dr. Weinland informs me that Emys europæa is known to produce a similar sound.

SECTION XII.

VASCULAR SYSTEM.

The heart of the Turtles lies just above the liver. It is broad, nearly triangular, the wide basis of the triangle extending across the body. It is inclosed in a double sac of the pericardium, and attached to it, at its point, by means of a fold of the pericardium. The plan of its interior structure is the same in Turtles as in Ophidians and Saurians. While in Crocodiles there exists a true septum between both ventricles,[1] as in Birds and Mammalia, we find in Turtles, typically, only one ventricle.[2]

In a large specimen of Ptychemys rugosa, (E. rubriventris,) we had an opportunity of studying the beating of the heart. The process is as follows: The auricles are filled simultaneously, one with a bluish red, the other with a light red blood. When filled to the utmost, they have a triangular shape, with rounded corners. But while the auricles are already thus filling, the heart itself, the ventricle, is gradually expanding more and more; then a sudden contraction of the auricles throws all the blood into the broadly expanded, but empty, ventricle, which thus filled assumes the form of a high cone. Immediately after this follows the contraction of the ventricle, then follows a pause until the auricles are filled again, and the powerful pump begins its play anew. This goes on about ten times in a minute. The rhythm in its details is as follows: First second, systole of the auricles; second second, systole of the ventricle; third and fourth seconds, the ventricle remains contracted; fifth and sixth seconds, the auricles are gradually filling; seventh

[1] This difference becomes, however, of less importance when we remember the fact, that in Crocodiles there exists, at their very base, a communication between the two trunks which start from the two ventricles of the heart, causing there a similar mixture of the dark and red blood, outside of the heart, as exists, in Turtles, inside of the heart.

[2] We cannot agree with the view generally adopted, that this so-called imperfect septum in the heart of Turtles, which seems to divide it into two cavities, a so-called cavum arteriosum and a cavum venosum, is homologous to the perfect septum between the ventricles which exists in Mammalia and Birds. The fact, that the great bloodvessels (the aorta and the arteria pulmonalis) start together from the cavum venosum, seems to prove that the two cavities in the heart of Turtles, which are by no means very marked, do not correspond to the two ventricles in Mammalia and Birds, but, on the contrary, that, as stated above, the ventricle in Turtles is typically one, as in Fishes. Yet this one ventricle of Turtles is not any more identical with the one ventricle of Fishes than with the two ventricles of warm blooded Vertebrata, for in Fishes we find only one vessel, the aorta, arising from it, while in Turtles, both aorta and arteria pulmonalis start together from it.

second, or first of the second contraction, systole of the auricles, etc. The whole rhythm was remarkably regular, except some variation in the measure of the last four seconds, which, as stated above, were generally thus divided into two pairs; but sometimes this division was not distinctly marked, the filling of the auricles beginning already in the fourth or even in the third second. As we have not found any important structural differences in the hearts of the most different families of Turtles, we are induced to believe that the rhythm observed in Emys rubriventris is probably the general rule for the contractions of the heart in all Turtles. This rhythm exhibits great uniformity, not only in the duration of the contractions as a whole, but also in the measure of its successive steps.

Three large vessels, intimately connected at their basis, which is sometimes supported by a cartilaginous frame, arise from the ventricle. Two of them, carrying red blood, soon form one common trunk, the aorta; but before this takes place, each of them sends off many vessels, namely, to the right the arteria anonyma, from which soon start the arteriæ carotides and subclaviæ, and to the left the arteries of the stomach and mesenterium.

The venous system of Turtles agrees with that of other Reptiles. Two venæ anonymæ from before, and two from behind, the umbilical veins of Bojanus, open into the sinus venosus, which pumps the blood into the right auricle. It is characteristic of the Turtles, that the venæ vertebrales — vena azygos of Bojanus, of which there are two, as in Saurians, while in Ophidians there is only one — run above the ribs in Turtles, while in all other Reptiles they run below the ribs. We find such veins in Turtles above the transverse processes of the vertebræ all along the dorsal column, and also in the neck and tail. There are moreover some veins, peculiar to Turtles, running from the liver directly to the heart, while in other Reptiles the vena cava receives all the veins of the liver. The blood of Turtles does not show different features from that of other Reptiles.[1]

[1] Its constituents, and its changes by starvation, thirst, etc., have been recently illustrated by Joseph Jones, q. a., p. 279. When taken from fresh specimens, the specific gravity of the blood of different Turtles varies from 1025 (Chelydra serpentina) to 1034 (Emys reticulata.) The amount of solid constituents in 1000 parts varies from 105 (Chel. serpentina) to 156 (Emys serrata.) The water in 1000 parts of blood varies from 895 (Chel. serpentina) to 843 (Testudo polyphemus); the dried organic constituents (blood globules) vary from 56 in Chel. serpentina to 87 in Testudo polyphemus. Thus, as was to be expected, the blood of water Turtles is more watery than that of land Turtles. Jones (p. 23) notices another difference in the color of the serum, namely, that, while in some Turtles (Testudo polyphemus) this color is light yellow, as in most Mammalia, Birds, Reptiles, Batrachians, and Fishes, it is golden in some Emydoidæ, (Emys serrata, reticulata, concentrica,) as it also is in the black Turkey Buzzard (Cathartes atratus.) With reference to the influence of hunger on the blood, we find the following experiment related in the same paper. Emys concentrica, recently captured, had on the 16th of June a weight of 14,285 grains. Kept without food and drink for forty days, weighed, July 23d, 11,400 grains. Loss,

The lymphatic system is very much developed in Turtles.[1] Two hearts, lying near the base of the tail, immediately under the bony shield, and provided with fat cushions for protection against pressure, form the pump-work of this vascular system. Like the blood-heart, these lymphatic hearts are provided with transversely striated muscular fibres. Lymph vessels bathe all the arteries of the body, surrounding not only the main stems, but running with them along all their branches. There lies a large lymph cistern between the lungs, opening into the ductus thoracicus, which leads into the venæ subclaviæ.

SECTION XIII.

UROGENITAL ORGANS.

Urinary Organs. We find that the so-called primordial kidneys, or Wolffian bodies, which exist in all Turtles, as well as in all other true Reptiles, are built up, as in these, of fine canals, sending off a duct into the cloaca. We have never found a distinct secretion in this duct. Investigations about their relation to the real kidneys and to the genital organs have led us to results which are in many respects at variance with those of other authors.[2] The urinary bladder of the Turtles is always more or less bilobed, and mostly onesided. It is remarkably large, and in land Turtles almost always filled. The ureters are short, the kidneys lying in the cavity of the pelvis, outside of the peritoneum. The kidneys are generally flattened, and composed of many lobes. Their weight, in relation to the weight of the body, varies much in different Turtles, and the laws about this variation are not yet clear;[3] but all of them have the kidneys two or three times smaller in proportion than other Reptiles.

Genital Organs. While in Turtles the kidneys lie outside of the peritoneum,

2885 grains. Amount of blood obtained, 400 grains; not more than one third the usual quantity. Solid constituents in 1000 parts, 199; water, 800. We quote this experiment only to show how intensively all the systems of the body are working on, even in this state of starvation, and how erroneous is the idea of a general torpor of such hungering animals.

[1] After this system had been first discovered in Turtles by Hewson, in 1769, and beautifully illustrated by Bojanus in 1819, J. Müller discovered, in 1839, the hearts which set it in motion. This important discovery of J. Müller seems, however, to be unknown to Rymer Jones, who, in the year 1852, in Todd's Cyclopedia, (Reptiles, p. 302,) denies the existence of these lymphatic hearts in Turtles. They are easily found in any living Turtle, and may be seen beating for a long time after being laid bare.

[2] See Part III. of this work, where this point is fully considered.

[3] See p. 127 of Jones's paper, q. a., p. 277, note.

the spermaries and ovaries are situated inside of it. The spermaries are oval, and surrounded by a convolution of seminiferous canals, the lumen of which is large, whilst their walls are often provided with a large amount of black pigment.[1] The spermatic ducts open into the cloaca on the top of a papilla near the opening of the urinary organs. The penis is single, large, and retracted into the cloaca, as in Crocodiles, while in Snakes and Lizards it is double, and lies outside of the cloaca.[2] The form of the penis, particularly its end, exhibits great diversity in different families, the extremity being simple in Testudo and Emys, for instance, while it is branching in Trionyx. The ovaries are very much as in Birds. The number of eggs which are matured in one year is, as in Birds, very different in different families, genera, and species. The eggs of the ovaries are largely provided with bloodvessels. The oviducts begin with a tender but large tuba, often provided with beautifully folded margins. In relation to the reception of the eggs through these tubæ, we have come, by numerous observations, to the strange result, that eggs from the left ovary are often received in the right tuba, and vice versa. This fact is clearly demonstrable. We have observed, in a large number of cases, that there were more corpora lutea to be found in the ovary of one side than eggs in the oviduct of the same side; and the eggs which were wanting in this oviduct were found in that of the other side, on which there accordingly appeared fewer corpora lutea than there were eggs in the oviduct. Whether this occurs only among Turtles, or, as we would rather believe, also in other Vertebrata, we do not yet know. During their passage through the oviduct, the eggs are provided with a thick, hard, calcareous shell, as in Crocodiles, while in all other Reptiles we find only a leathery shell. In connection with this, Lizards and Snakes have, while hatching, a sharp tooth, to cut through the shell, as with a knife.[3] In Turtles, we find only a hard tubercle upon the snout, by

[1] We do not find ripe semen in the seminiferous ducts of the young Emys picta (of which we had a large series from the first year upwards) before it has attained the seventh year of its age.

[2] Stannius has established a primary division, among the Reptiles, upon this difference, and that other peculiarity of a free movable suspensorium for the lower jaw in Saurians and Ophidians, which, on the contrary, is immovable, and soldered by sutures to the skull, in Crocodiles and Turtles; Handbuch der Zootomie, Amphibien, Berlin, 1856, p. 5 and 7. He there calls the Reptiles, Amphibia monopnoa; while the two large sections, founded upon the characters mentioned above, are his Streptostylica, embracing the Ophidians and Saurians, and his Monimostylica, the Crocodiles and the Turtles. Though we acknowledge a nearer relation between Snakes and Lizards, and a greater difference between Saurians and Crocodiles, than is generally admitted, we cannot see, on the other hand, a real relationship between Turtles and Crocodiles. There is, at least, no more affinity between them than between Saurians and Turtles; and, though a group comprehending Turtles and Crocodiles may be convenient in an anatomical point of view, it seems to us at the same time artificial.

[3] This tooth was discovered by Johannes Müller, (see his Archiv für Anatomie und Physiologie for

means of which the young, like young Birds, break through the hard shell. Dr. Weinland tells me, that in a beautiful series of specimens of Crocodiles in the Museum of Berlin, the snout of the embryo about hatching is sufficiently hard to break the egg, and that there is no such tubercle upon it; neither is there a tooth in the intermaxillary bone for this purpose.

The cloaca is very large in both sexes; it opens on both sides into a large pouch, (sacci anales,) the function of which is not yet fully ascertained; it may stand in connection with the reception of water into the cloaca, mentioned above. The cloaca is exceedingly long in Trionyx. In female Turtles, we see in the bottom of the cloaca a longitudinal furrow, with thick, rounded walls, running out generally into fringed appendages behind. This serves as a vagina in the act of copulation. Interiorly we find, in the cloaca, first, the opening for the urine, then behind and outside of it, on each side, that for the oviduct.

The copulation is generally said to take place only once in a year; but my observations have satisfied me, that, at least in some species, it takes place twice every year, namely, in the spring and in the autumn.

It is, perhaps, the proper place to mention here some glands in Turtles which open outward and secrete a strong, odoriferous oil. These glands seem to have a more immediate reference to the relations of the animal to its fellow-beings than to its own individual organism. We find such glands in the lower jaw in Testudo, in the neck and shoulder region in sea Turtles, while in the family of the Cinosternoidæ there are two larger glands on each side under the carapace, near the bridge which unites the carapace and plastron, the excretory ducts of which

the year 1841, p. 329 and foll.) The operation of the tooth itself in the living animal has been observed in young Snakes, while hatching, by Dr. Weinland, (see Württembergische naturwissenschaftliche Jahreshefte, XII., for the year 1856, p. 90 and foll.,) so that there can be no doubt about the function of this strange tooth, which is fixed in the intermaxillary bone, where afterwards, at least in most Snakes, no tooth at all is to be found. Nor can there be any question of its being common to all Snakes and Lizards, when hatching, for after Müller had already found it in very different families, it has been traced by Dr. Weinland in all the German Snakes and Lizards. Now neither J. Müller nor Dr. Weinland could find this tooth in the young Crocodiles when hatching. This is remarkable, because it strangely coincides with the suggestion of Stannius, (see above, p. 288, note,) to unite the Snakes and Lizards on one side, and the Turtles and Crocodiles on the other side, into two large groups; the first of which have such an egg-tooth, whilst the latter have none. But, as far as the Turtles and Crocodiles are concerned, this resemblance is evidently only negative, and cannot, therefore, prove any affinity; while the fact, that the egg-tooth is common to the Lizards and Snakes, is another striking instance of their close affinity, and of the correctness of the views of Stannius, who proposes to unite them into one group, in opposition to Turtles and Crocodiles, as Merrem has already done. Thus, the Reptiles would really form only three large groups, one comprehending the Lizards and Snakes, another the Crocodiles, and a third the Turtles.

run through the bone and open outward by a fine slit in that bridge. The Crocodiles have one large musk gland on each side near the inner and lower edge of the two branches of the lower jaw, not far from their posterior angle. The position of these glands is nearly the same as in Testudo. Many Saurians have similar glands on the lower surface of the thigh. In Chelydra there are no such glands, though they emit a musk-like stench, quite as strong as that of the Cinosternoidæ. It is however possible, that in this family the odor arises from a large number of small glands opening between the warts of the skin; but I neglected to examine this point in the proper season. Though the product of these glands may be of some use in keeping the skin fat and elastic, still its more important function may be to enable the sexes to find each other at the time of copulation, as we observe it so plainly in Snakes.

SECTION XIV.

THE DEVELOPMENT OF TURTLES FROM A ZOÖLOGICAL POINT OF VIEW.

The growth of Turtles is exceedingly slow. In this respect they differ greatly from the Batrachians, which complete their growth, either entirely or nearly so, during the first year of their life. The true Reptiles, on the contrary, acquire slowly the age of maturity; and among them the Turtles are the slowest in their growth, and acquire latest, as far as we know, the period of puberty. I have collected data which prove satisfactorily that our common Emys (Chrysemys) picta does not lay eggs before it is ten or eleven years old; and even then it is by no means full grown.

Like most other Reptiles, Turtles lay their eggs either in moist ground, or in dryer places near the water, (fresh-water Turtles,) or in dry ground, (land Turtles,) or in hot sand, (Chelonioidæ.)[1] The embryo breaks through the shell of the egg by means of the horn it has upon its snout, (see above, p. 288,) after an incubation varying, in different genera or families, from six weeks to three or four months and even more.[2] The outline of the carapace of all Amydæ, at the time of its formation, is remarkably similar, namely, ovate, or orbicular and flat; at least, this is the case with all the young which I have had an opportunity to see. There may be an exception with reference to these features in Testudo only,

[1] Respecting the laying of the eggs, more will be found in Part III.

[2] For more details respecting the act of incubation, see Part III.

which I have not seen in its youngest state. In the Trionychidæ, this flat, orbicular form is preserved through life, and in the Emydoidæ during the first four or five years, at least; but by and by the shield assumes the more or less elliptical and higher form of the adult, according to the different genera and species. This change takes place earlier in the Chelydroidæ and Cinosternoidæ than in the Emydoidæ, and earlier still in the Chelonioidæ.[1] In this last family, the characteristic features of the adult are already sketched out in the first year, though not yet fully developed. In the family of Chelydroidæ, the embryonic characters are prevalent for two years at least; in that of Cinosternoidæ the characters of the young do not disappear before the fourth year. It is nevertheless true that each family has its special pattern.

The young Turtles are mostly so different from the adult, in all their features, that it is very difficult to identify them. At all events, it requires a long experience to recognize them, in these first years, for what they are. Our systematic works, even the most recent, furnish, in fact, the painful evidence that these young Turtles have repeatedly been mistaken for distinct species. On the other hand, it is worth mentioning, that Turtles belonging to the same genus, as the genera are circumscribed below, show already in the youngest state slight peculiarities which at least indicate the genus, though the generic characters are by no means all developed. In the family of the Emydoidæ, I have further observed that the young approximate the lower Testudinata, not only by their remarkable similarity with the Chelonioidæ in the earlier stages of their embryonic development, but also by their mode of life, which is much more aquatic than that of the adult of the same species. This agrees remarkably well with the law, which seems to exist throughout the animal kingdom, that aquatic animals rank lower than the terrestrial representatives of the same groups.[2] It may be remembered in this connection, that in a large number of Insects the larvæ live in the water, while the perfect Insects are entirely aerial. Still greater differences, in the mode of life and the form of the young and adults, may be observed among parasitic Worms. Among Vertebrates, similar differences are particularly obvious in the class of Batrachians, in which the young of some of their representatives are entirely aquatic, whilst the adults live exclusively upon land. At least, this is the case for the highest among them, the Toads. These remarks in relation to the development of the form, and the mode of life, which is more or less connected with the form, may be sufficient to show how important the study of young animals is with reference to a correct appreciation of their true relations.

The following table gives a complete view of the changes which our common Chrysemys undergoes in its form.

[1] See Part III. for further details.

[2] Compare Part I., Sect. 9, p. 30.

TABLE,

SHOWING THE SUCCESSIVE CHANGES IN THE RELATIVE DIMENSIONS OF THE BODY IN EMYDOIDÆ.

Species.	Age.	Sex.	Height of the Box.	Dorsal Shield. Length.	Dorsal Shield. Breadth in the Middle.	Ventral Shield. Length.	Ventral Shield. Breadth in the Middle.	Length of the Tail.
Emys picta, *Auct.* Now Chrysomys picta, *Gray.*	Second year.[1]		12 Mil.	26½	25	25	18	16½
	Third year.	Male.	17	42	39½	37	24	17½
	Fourth year.	Female.	21½	51	49	44	37½	20½
	Fifth year.	Female.	23½	54	51	50	39	21½
	Sixth year.	Female.	25	59	56	54	42½	23½
	Seventh year.[2]	Male.	26½	66	60	60	47	26
	Seventh year.	Male.	27	67	60	60	47½	26½
	Eighth year.	Male.	28	72½	61	68	50	27½
	Ninth year.	Male.	28	74	62	70	50	27½
	Tenth year.	Male.	30	77	64	73	53½	28
	Eleventh year.	Male.	30	80	67	76	54	28½
	Fourteenth year.	Male.	33	92	74½	85	60	28½
	Twenty-fifth year.	Female.	43	121	92	113	80	34
	Old.	Female.	47	129	96	120½	81	37
	Very old.	Female.	59	163	113	154	95	53
Chrysemys (Emys) Bellii, *Gray.*	Sixth year.	Male.	29	68	59	63	47	27
	Old.	Male.	35	99	77	92	63	40
	Very old.	Female.	59	155	110	145	93	50

There is another feature which, though of less importance, still allows a generalization worth mentioning, I mean the change of color in Turtles of different

[1] As Turtles lay their eggs in the spring, the specimens selected for examination were all collected in the spring; the starting point of comparison is, therefore, really the second year of their development. However, as the eclosion takes place only late in the summer, the young had only been hatched six months when picked up, though they are considered here as one year old, on account of the long period of incubation. Moreover, there is very little difference between specimens recently hatched and those collected the following spring.

[2] After the seventh year, it is much more difficult to distinguish the age of those Turtles, which, like Chrysemys picta, have a perfectly smooth epidermis, than during the earlier years. I have, however, been able to determine it with tolerable precision, by collecting large numbers of specimens at the same time and in the same season, and assorting them according to their size, and comparing the sets thus formed with specimens of other species, in which the successive lines of growth indicate the number of their years. During the first six or seven years the rate of growth is so uniform that numerous specimens collected at the same time are readily arranged in sets of the same age, simply by the difference they show in their size.

ages, and the simplicity of their forms. As a roundish form is an attribute of the young, which we may trace throughout the animal kingdom, so also has simplicity of ornamentation, particularly of color, been considered as characteristic of the younger age. Most Birds furnish examples of this law, in their monotonous gray plumage at the time of hatching, when contrasted with the beauty, gayety, and variety of colors in the adult. But in Reptiles this law is not so obvious, and there are even very striking exceptions, if the opposite is not actually to be considered as the rule. A Boa constrictor, a striped Snake, a Rattlesnake, when hatching, show the same purity of colors as the adult, or even a greater brilliancy. The same seems to be the case with Turtles, if we compare, for instance, the beautiful network of yellow lines in Graptemys Lesueurii and geographica, when hatching, with the pale colors of the adult. Still, the law mentioned above is maintained, at least thus far, that few young Turtles have really purer colors than the adults. Yet there are some, which in middle life are more brilliant than either in their earlier years or in old age. This is, for instance, the case with Ptychemys concinna, (E. floridana,) and rugosa, (E. rubriventris,) and with Emys Meleagris, (Cistudo Blandingii.) From all those instances which I have investigated more thoroughly, it may be inferred that the fading of the colors in adult specimens is either owing to the thickness of the grayish epidermis, which thus obscures the Malpighian layer, in which the color resides, or to external mechanical influences which injure the smoothness of the epidermis.

In order to illustrate this subject more fully, I add in a note more minute details relating to the development of Chrysemys picta, not only as far as its form is concerned, but also respecting its colors. A large series of specimens of all ages, from the youngest, just hatched, to the adult, including very old ones, collected in the same season of the year and at the same time, enables me to present this sketch.[1] I have selected this species to illustrate the changes which

[1] When comparing young specimens of our most common Turtles with adult ones, our Emys picta for instance, when just hatched, there are three points which strike us at first sight. A large, full head, a circular, flat carapace, and a long tail, vertically compressed. The head, at first almost a regular ball with three prominences, the two large eyes and the nose, becomes in more advanced age more and more pyramidal; it has in the adult four distinct sides, a very flat upper surface, two lateral surfaces, which are slightly bent, and a flat under surface. But it is remarkable, that in Emys concentrica, and also, though in a less degree, in the type of Emys floridana, that youthful form of the head continues throughout life. This is more remarkable still, if we remember that just these species are the most aquatic among Emydoidæ, and further that our young Emys picta is itself much more aquatic in its habits, during the first years of its life, than it is in later life. In relation to the changes of the forms of the carapace, I have presented these in the shape of a table, in which the differences arising during the growth, in the relative proportions of the different diameters of the body, may be seen at a glance. See p. 292.

Thus we may say that this Emys, for the first four or six years of its life, has the shape of the

Testudinata undergo with age, not only because I have been able to obtain a much larger number of specimens, but chiefly because I have had ample oppor-

carapace of a Trionyx, and that like this, it lives almost exclusively in water. This is also the reason why, in spite of the much larger number of young than of adults, (which exist no doubt among these animals, as in most species throughout the animal kingdom,) the young Emydoidæ are still so rare in our museums, and almost unknown to zoölogists. Nothing could prove more directly this difference in the mode of life of the young and the adult than the fact, that though Emys insculpta is so common in the neighborhood of Lancaster, about forty miles from Boston, that I have at times collected over one hundred in an afternoon, aided by a few friends, I have never yet been able to obtain a single young specimen of the first year, even though a whole school of young men were called to aid in the search. Professor Baird has found the same difficulty in obtaining young Emys rugosa for me, and though he offered a high price for them, he could not obtain more than a single specimen of the first year. And yet this species is so common, that, in the season, hundreds are daily brought to the market of Washington.

By and by the bulk of the body becomes more concentrated in the middle; the lungs of land species, being larger in proportion than those of aquatic ones, (see above, p. 283,) require a larger development of the carapace in height; and Emys picta of the seventh year, which is now ready to go from time to time on land, assumes at this age the shape of the Nectemyds. Then it approaches more and more the rounded form of the land Turtles; this is, however, never reached in this species, though it is actually the case in a higher genus of Emydoidæ, the terrestrial Cistudo.

The retrograde development of the tail, as shown in our table, furnishes another proof of the truth of these comparisons. At first, in the hatching Turtle, the tail is vertical, compressed laterally, and very long in proportion to the size of the animal, indeed, nearly as long and powerful as in Chelydra, and, like the tail of a Tadpole, serves as a kind of rudder, strong enough to direct the course of that living flat-boat with its four paddles. Thus, as in the flying Bird, the tail is to be looked upon as a locomotive organ. But afterwards it does not grow in the same proportion as the body; and while in the young it was one of its most important parts, it is, on the contrary, in the adult, a mere appendage to the body, weak and useless for the locomotion of that heavy bulk. I may add here, that the tail is also rather long in Trionychidæ; and that in the family of Chelydroidæ it is most powerful, and clearly subservient to locomotion, in darting the body forwards or in turning it over when on its back; while in Cistudo it nearly disappears, or at least loses all significance.

Again, the legs, in their development in the young as compared with the adults, show similar metamorphoses, though not in the same degree in our species as in some others, E. guttata or insculpta, for instance. Being really broad paddles in the young, they become stiffer and more compact in the adult, to suit their habit of walking on the land, as well as swimming in the water. In Cistudo, the highest Emydian, they have reached the form of feet adapted to walking, instead of broad paddles, and so we find the slender fingers soldered together. In one species of this genus, one of these fingers has even faded away to a single phalanx, which does not reach beyond the skin, or only shows, when young, a very small nail projecting sideways.

We now proceed to a comparison of the horny plates of the young E. picta with those of the adult. I would also refer to the Plates I., II., III., and IV., which exhibit accurate drawings of the young of a number of other species of our Turtles. Pl. XXVI. represents, besides, several young Ptychemys rugosa, (Emys rubriventris,) and Pl. XXVII. adults of the same species in different varieties of color. A glance at the horny plates of both shows a great difference in form. The following changes take place in the development of these plates in Chrysemys (Emys) picta. The plates of the dorsal side of this tunities of watching it for ten successive years. The other species, of which I possess less extensive series, are described in the following, third, Chapter.

Turtle, when hatching, are angular, when adult, rounded; the median ones are twice as broad as high in the young; they are as broad as high, or even higher than broad, in the adult. Granulated in the young, they are smooth in the adult. The granulated plate of the first year continues in some land Turtles, and also in Cistudo virginea, sometimes throughout life, as the centre of the plate. In Chrysemys, and in most Emydoidæ, the plates become entirely smooth after the second year. We meet similar discrepancies in reference to the plates of the plastron. While in the young they have all the same longitudinal diameter, they are of very different length in the adult, the three posterior pairs, particularly the second pair of the connecting plates, becoming much higher. All these changes in the form of the plates are, of course, connected with the changes of the general form of the carapace, as described above. We find, for the first time, the form of adult plates in specimens about six years old. But I must mention here a remarkable exception, which I once met with in this species, namely, a fine specimen of more than seven years exhibiting still all the forms of the plates of the young when hatching.

We observe similar changes with reference to colors. In Chrysemys picta just hatched, the back is of a dark gray brown color with a yellow middle line. The marginal plates are red above, each with three semicircular bands, the lowest one the broadest; they are red below, with a black circle. The plastron is red, in some specimens with a black, bottle-like mark in the middle, occupying the inner margin of all the plates of the plastron. The head is brown, with yellow stripes; a yellow spot behind each eye, and a broad, club-like band on each side running behind, are particularly conspicuous; over these there are yellow spots along the neck. Similar bands, forked in front, extend from the angle of the mouth to the fore leg; two other yellow bands are seen along the under-side of the neck; and finally, a short, imperfect one runs backwards from the middle of the lower jaw, not touching the former ones, as in the adult. The fore legs have one red middle stripe in front, and another, very short, above it. All phalanges have reddish lines. The hind part of the fore leg is dark brown, with some little white spots. The hind legs are dark in front, with two yellowish bands behind, the lower one originating from the base of the tail, where it meets that from the other side, and hence forms one stripe along the under-side of the tail. The tail is marked above in the same way by a yellowish line, forked near the root. In the dress of the Turtle during the second year, there appear entirely new yellow stripes across the back, coloring the anterior margin of the plates and joining the yellow median stripe, which grows then much broader. Moreover, the plastron is no longer red, but yellow. The black mark upon it, if it still exists, extends only from the fourth pair of plates to the last. All the stripes upon the legs and feet are no longer red, but yellow. In the third year, the colors are brighter, especially the yellow cross bands on the back, which now turn reddish, extending more and more over the margins of the plates, with the exception of the exterior margin. The marginal plates, light red until now, change into a splendid purple. In the fourth year, we see already all the colors of the adult, though the Turtle of this year is not yet half-grown, and though its general roundish form, as well as the form of the head, of the tail, and of the single plates, still exhibits rather the youthful than the adult characteristics. (Comp. the table above, p. 292.)

It is interesting to follow out the same development in another Emydian, Chrysemys Bellii, which is very nearly related to Chrysemys picta. The organic laws of its development are exhibited in the same way as in Chrysemys picta, but we learn here that the specific character, so far as the coloring is concerned, namely, that black, bottle-like mark, (which we find so largely developed in the adult Chr. Bellii, while it is entirely wanting in the adult Chr. picta,) is already very

SECTION XV.

THE PSYCHOLOGICAL DEVELOPMENT OF TURTLES COMPARED WITH THAT OF THE OTHER ORDERS OF REPTILES.

It is a question of the greatest interest, and one which must arise in the mind of every reader who has entered into the spirit of the First Part of this work, whether the psychological development of animals rises in the same degree as the development of the complication of their structure generally. If this be the case, it follows directly that the rank of the orders expresses at the same time the range of their psychological development. And we think that this is really the case. Now since we have shown that, owing to the complication of their structure, the Turtles are really the highest order among Reptiles, we must expect to find in them also the highest psychological development of the whole class, higher indeed than that of Lizards and Snakes.

But, to measure the psychological development of animals is one of the most difficult tasks in natural science, since it can only be done by a comparison of those functions through which the mental energies are manifested, and the gradation and intensity of which are not so easily ascertained as those of other organs. These functions are, the sensations and the motions.

With reference to the sensations, it cannot be doubted that they stand in

distinct in the young animal when hatching, more so indeed than in Chr. picta, in which, as stated above, I have sometimes seen such a mark when young; and while it now increases in Chr. Bellii, it disappears entirely, in the two or three following years, in Chr. picta. Then again, in relation to the form, we find that the specific character of the carapace, by which Chr. picta and Chr. Bellii are so easily distinguished when adult, (the large diameter of the hind part of the shield in comparison to its front part, as we meet it in Chr. Bellii, while in Chr. picta both these diameters are nearly equal,) only appears about the seventh year. Thus, we see that in this development there is not a definite and regular series in the appearance of specific, generic, family, and ordinal characters; a specific character may appear, while the family character is not yet marked. The young Chrysemys Bellii, when hatching, has really in its forms, which constitute family characters, not much more relation to the family of Emydoidæ than a Trionyx, when hatching, while it already exhibits its specific coloring in contradistinction to that nearly allied species, Chr. picta. The idea that an animal, in its development from the egg, exhibits first, class, then order, then family, then generic, then specific characters, may be true in some cases, but it is certain that in most species this is not the case. On the contrary, I do not hesitate to say that there are many animals which exhibit in their youth the characters of a different family from that to which they really belong when adult. It is evident that if this be the case, the supposed law, above alluded to, is positively denied in nature.

direct relation to the development of the organs of the senses and of the brain; while the motions are dependent upon the development of the muscular system.

Now, accurately to determine the standing of the Turtles in their class, as far as their psychological development is concerned, a glance at the position of the whole class, in its branch, may furnish some valuable hints. Though the orders have been represented[1] as the natural groups which, being founded upon the complication of the structure of animals, above all determine their relative rank, it is equally true, that the classes, when compared with one another, stand lower or higher, in proportion as the systems of organs which are developed in them have a higher importance, or are built upon a more perfected pattern. In the branch of Vertebrata, there can be no doubt that the class of Fishes, as a whole, occupy the lowest position, that Amphibians rank next to them, that Reptiles come next, that Birds stand above these, and that Mammalia are the highest. Their whole structure shows this plainly. But, to consider only the points which have a bearing upon the question under consideration, it is obvious, that the Fishes, in which the whole bulk of the body is one undivided mass, the vertebral column continuous in one horizontal line with the base of the skull, the muscular system uniformly extended over the whole trunk, so as to allow only lateral motions, and the limbs reduced to branching digitations without concentrated activity; in which the brain is only a slight enlargement of the spinal marrow, and some of the organs of senses are either wanting or very imperfect, while the others are rather blunt and obtuse;—it is obvious, I say, that this class occupies, not only structurally, but also with reference to its psychological endowment, a much lower position than the classes of Amphibians and of true Reptiles, in which the different regions of the body are more distinct, the motions more localized, the organs of the senses more perfect, and the brain larger.

In these two classes, the preponderance of the head is already fully indicated by its position, being somewhat raised above the bulk of the body and forming with it a more or less marked angle, whilst in most of them the limbs are detached as locomotive appendages, distinct from the trunk, though not yet so free as to move with perfect independence. In Birds and Mammalia, the progress is still more distinct. The different regions of the body are not only better marked, they are also more diversified in their structure; the body is no longer so prone upon the medium in which the animal lives; the head has acquired a special movability in connection with the highly organized organs of the senses, the larger brain and the commanding position it has assumed; the motions also are more diversified, not only in themselves, but the anterior and posterior pair of

[1] See Part I., Chap. 2, Sect. 3, p. 150.

limbs are even sometimes adapted to different purposes. All these features are brought to a climax in Man, whose vertical station presents the highest contrast with the horizontal position of the body in Fishes; whose head is so raised as to stand free above the whole frame, while the hands have become the willing tools of the manifestations of his mental powers. The gradation, as far as the structure is concerned, is as evident as possible, from the unwieldy, massive, horizontal body of the Fish, up to the commanding attitude of Man; and that this structural gradation stands in immediate correlation to the degree of the psychological development is equally evident, when we compare the mental powers of Man with the imperfect faculties of the Fishes.

With reference to the motions in particular, Dr. Weinland has presented very interesting considerations, in a paper read not long ago before the Boston Society of Natural History.[1] He remarked, that there exist in animals two kinds of motions, entirely different from one another, which, however, have not as yet been duly distinguished. If we watch attentively the motions of a dog, for instance, we soon perceive that they are partly subservient to himself only; such are his motions when eating, drinking, etc.; while he performs many other motions with his eyes, his ears, his tail, his whole body, by which he evidently intends to show to other animals or to Man, the state of his mind, what he thinks, feels, or wants. Dr. Weinland calls the first kind of these motions "subjective;" the second, "sympathetic." He showed that the first are common to all animals, while the second appear only in the higher types,[2] and culminate in Man. Moreover, the higher perfection of the organs for sympathetic motions, as observed in Man, expresses at the same time his higher psychological standing. The gradation observed in this respect, in the different classes of Vertebrata, is not less appreciable. The Fishes, lying horizontally in the water, move simultaneously the whole body by the lateral bendings of the vertebral column, and the fins perform only locomotive functions; the eyes are little movable, and without expression. Fishes have no voice, indeed hardly any means by which they can communicate with their fellow-creatures, and yet they may be seen moving together in such a manner as to indicate a kind of concert; I have even observed some playing with one another.

In Batrachians and Reptiles, the sympathetic motions are already more varied, the relations of the individuals of the same species to one another are more extensive and more frequent, and their ability to emit sounds almost universal, though these sounds are still very monotonous. With the Birds and Mammalia, all these

[1] See Dr. Weinland, "On the Motions of Animals," in Proc. Boston Society of Nat. History, 1856.

[2] It is impossible, for the present, to extend such investigations to the faculties of Invertebrata.

relations become more intimate, and acquire a character of intensity unknown among the cold-blooded Vertebrata. In Man, the vertical station renders the whole body better adapted to perform sympathetic motions, and the organs themselves, by which they are performed, are more perfect; the hand especially, still a locomotive organ in the Monkeys, is, next to speech, the most expressive organ of Man. With it he strengthens his word; with it he grasps the hand of his fellow-man; with it he presses his mate upon his heart. Need I add, how expressive are the lips, the eyes, the tongue, the organs of the voice, and even the attitudes of the body, in giving utterance, by their diversified play, to our thoughts, our feelings, and our emotions — joy, love, grief, or hope!

In this series, the true Reptiles occupy an intermediate position between the Batrachians and Birds. But if we apply the same test to the Turtles in particular, we cannot fail to see that, as the complication of their structure assigns to them the highest position in their class, so also is their psychological development highest among Reptiles. No one can fail, on the contrary, to see that the place assigned to the Snakes, at the bottom of their class, while the Lizards stand in an intermediate position between them and the Turtles, is as well justified in a psychological point of view as it is by the complication of their structure. Their whole body is used for locomotion; there are no limbs; the head and neck are buried in the uniform cylindrical body; the eyes are nearly immovable; there is no voice but a kind of hissing, which may express at times fear, at other times fierceness. This, and certain bendings of the whole body, or an uplifting of its front part or of the tail, and a feverish shaking of the latter, as we see it particularly in some poisonous Snakes when near their prey, are the only motions by which Snakes show to other animals or to Man, the state of their mind. Fear and ferocity are indeed the only psychical emotions which have been observed in Snakes by the most attentive observers. If we compare a Snake near its prey with a Lizard in the same employment, we may admire the shrewd prudence of the latter, while we are astonished at the awkwardness of the former. The Lizard, turning its head now on one side then on the other, watches carefully the fly it has espied, and at once catches it by a quick motion, which he makes, however, only when sure of success. On the contrary, we may often see Snakes striking again and again in the direction of their prey before they catch it. There are moreover no eyelids in Snakes, while they are much developed in Lizards, and capable of the liveliest motions. The eyelids render the eyes of the Lizard expressive, and from these alone we may ascertain whether they are lively or depressed, while the eyes of the Snake are unexpressive, cold, and unchanging. Snakes see only; Lizards look. And now what is the further step of psychological development made from the Lizards to the Turtles? The neck, in the first place, has become still freer than in Lizards; and secondly, the head moves independently of the neck, which was not yet the case in Lizards. With this structural condition, the foundation is laid for a higher and more conscious relation to the surrounding mediums than is observed in Lizards. The ability to move the head freely upon the neck furnishes a larger horizon for the senses, which are situated in the head, and by this a more extensive and more accurate perception of the surrounding world may be obtained than we can suppose in those animals in which the neck is buried in the body, as in Fishes and Snakes, or in which the head at least is buried in the neck, as in Lizards. But even the legs, which, as in Lizards, seem to be subservient only to locomotion, perform in addition, in Turtles, functions which we would hardly suppose in these animals. Professor Jeffries Wyman had once the rare opportunity of watching two Chrysemys picta while making love, and he saw the male caressing and patting the head of the female with its fore feet for several minutes. Thus among Reptiles the fore feet have become, in Turtles, organs for sympathetic motions; but we are not aware how far this is extended to the whole order. Moreover, the voice of Turtles is superior to that of Lizards, which are only able to emit that hissing sound which is common to all Reptiles.

In conformity with this higher psychical endowment of the Turtles, their brain is much more developed than in the other Reptiles, particularly the large hemispheres.[1] Still it is true, that Turtles are in some respects more insensible than other Reptiles, or at least than Lizards. They resist hunger and thirst, and the effect of wounds, easier than Lizards. This shows, no doubt, a slower process of change in the materials of which the body is built up, and accordingly also a lower vital energy generally. But, on the other hand, we must not forget that our observations of the habits of Turtles have for the most part been made upon individuals kept in captivity. If we walk along our ponds, and watch our Emydoidæ, sunning themselves on the shore, or on logs floating upon the water, they are by no means so slow and lazy as they are so generally supposed to be. They may, on the contrary, be seen attentively looking around and stretching out their neck to the utmost, as if listening. At the slightest noise of our steps, and with a quick motion of their paddles, they disappear under the surface of the water. If, now, in captivity, the same animal becomes more or less awkward and slow, we ought to remember, that the higher an animal stands, the more it feels the privation of its liberty; and my long experience with Turtles has satisfied me that they do feel the change, when confined in narrow enclosures.

[1] See above, Sect. 8, p. 274.

SECTION XVI.

GEOGRAPHICAL DISTRIBUTION OF THE TESTUDINATA.

The distribution of the Testudinata upon the surface of our globe presents some very interesting features, which deserve the more to arrest our attention, as they bear directly upon the very principles which regulate the geographical distribution of the animals in general. In the first place, we find that, taken as a whole, the range of the Testudinata is less extensive than that of the other orders of Reptiles. This agrees with the general fact, that the higher representatives of any comprehensive group are everywhere more limited in their distribution than the lower types of the same group; and as we have seen that the Testudinata are the highest Reptiles, we should expect to find them, as is really the case, occupying a more limited area of the surface of the globe than either the Saurians or the Ophidians. This is equally true of their horizontal and of their vertical range. A few Saurians, and some Ophidians, especially of the family of Vipers, extend much farther north, and much higher up, along the slopes of the mountains, than any Chelonians. In the second place, it is known that the sea Turtles, the Chelonii proper, which constitute the lowest sub-order of the Testudinata, have a much wider range than the land and fresh-water Turtles, the Amydæ. This fact is important in two different points of view: first, as corroborating the assertion, already made above, that the lower representatives of any comprehensive group have a wider distribution than its higher types; and secondly, as showing that the mediums in which the lower types dwell are frequently different from those which suit the higher ones. It is a fact, that though the Testudinata, as a whole, have a more limited geographical range than the other orders of Reptiles, the sea Turtles, which are unquestionably the lowest Testudinata, are by far more widely diffused upon the surface of the earth than either the land or fresh-water Turtles. They are common to all oceans, being found in the North and South Atlantic as well as in its warmest waters; in the Mediterranean, in the Indian Ocean, and over the whole range of the Pacific. Moreover, marine Turtles have been observed in northern latitudes, far beyond the range of other Turtles; they are, indeed, the only ones seen, and that but occasionally, along the northern shores of Europe and of Eastern Asia. It is not less characteristic, that these Chelonii, which are the lowest of the Testudinata, are at the same time all marine, while the Amydæ, which constitute a higher sub-order, never live in the ocean, but only upon land, either in fresh water or upon dry land.

In the sub-order of Amydæ, the same features which characterize the Chelonii obtain again, though within still more restricted limits. The aquatic Amydæ have a wider range than the terrestrial; and while the lower representatives of the sub-order are fluviatile, the higher are terrestrial. The lowest Amydæ, the Trionychidæ, have truly the widest distribution; for while in the Old World they are chiefly limited to the tropical fresh waters, in the New World they are only found within the temperate zone of North America, extending as far north and as high in the mountains as any other Turtles, indeed much farther north, and higher up, than any land Turtles, and even beyond the natural boundaries of the Emydoidæ. The family of Chelydroidæ is already much more restricted in its range, being limited to the temperate zone of the eastern side of the North American and of the Asiatic continents. The Chelyoidæ, on the contrary, are circumscribed within the fresh waters of tropical South America; whilst the Cinosternoidæ extend over the temperate parts of North America, over Central America, and over the warmer regions of South America. The Hydraspids, on the contrary, prevail in South America, and extend also to Southern Asia, to Africa, and to New Holland. The family of Emydoidæ, which is, as it were, the central type of the Amydæ, is the only one among the fresh-water Turtles which has representatives simultaneously in North and South America, in Europe, in Africa, and in Asia, though the range of the individual species is very limited in this family also, much more so, indeed, than the species of the lower families of the aquatic Amydæ, or those of the Chelonii. The highest Amydæ, the Testudinina, or land Turtles, are the most limited in their range, if we contrast them with the whole number of fresh-water Testudinata, for they do not extend beyond the limits of the warmer parts of the temperate zone, while the aquatic Amydæ are not only found in the tropical fresh waters, but also in those of the warm, and even of the colder parts of the temperate zone. It may perhaps seem unnatural, that I should thus contrast the Testudinina, which constitute only one family, with the many families of fresh-water Amydæ; but it is just the object of physical geography to ascertain what are the natural relations between the physical conditions of the surface of the globe and the organized beings which live upon it.

I shall enter into more details respecting the special distribution of the North American Testudinata, after I have considered more fully their generic and specific relations to one another. There is one more point, however, which deserves to be noticed in this connection. The Chelonii proper, which are the lowest, and at the same time the only marine Testudinata, are also the largest representatives of the whole order; next in size are some of the fresh-water Amydæ, of the family of Chelydroidæ, which are very large, as are also some of the Testudinina. The average size of the fresh-water Amydæ exceeds, nevertheless, that of the terrestrial ones, though the smallest of all Testudinata are fresh-water species. But it must not be forgotten, that these belong to the temperate zone, while the largest land Turtles are exclusively tropical. Gigantic Testudinata, approaching the size of the largest land Quadrupeds, are known among the fossils.

SECTION XVII.

FIRST APPEARANCE OF TESTUDINATA UPON OUR GLOBE.

Though the period of the first appearance of the Testudinata upon the surface of our globe has been a point of discussion among naturalists, even within the last few years, I do not intend to enumerate here the fossil representatives of this order, now satisfactorily known, nor even to compare the different Turtles which have existed, in former ages, in North America, with those now living. My object, for the present, is simply to point out the period at which this remarkable type of animals first made its appearance, and at the same time to show how important critical investigations are with reference to the affinities of fossil and living animals, and how utterly impossible it is to arrive at any general result respecting the order of their succession in time without such a close and careful study. Only five years ago, Sir Charles Lyell published a supplement to the third edition of his Manual of Elementary Geology,[1] intended chiefly to sustain the view that Reptiles had existed much longer upon the surface of our globe than was generally supposed, and that the Chelonians in particular could be traced back to the Potsdam sandstone, that is, to the lowest stratified set of beds in which fossils had been found at all. The identification of these animals rested upon footprints which had been examined by Professor Owen, who published a description of these impressions early in the year 1851.[2] This report has since gone the rounds of all the scientific and other periodicals, and is now repeated in almost every modern text-book of Geology and Palæontology, though Owen himself has recognized his mistake,[3] and in the following year published his opinion, that

[1] Lyell's Manual of Elementary Geology. Postscript to the third edition, London, December 10th, 1851.

[2] Description of the Impressions on the Potsdam Sandstone, discovered by Mr. Logan, in Lower Canada, Quarterly Journal of the Geological Society, London, 1851, vol. 7, p. 250.

[3] A few days after Professor Owen had read his first notice in London, an abstract of it was communicated to the American Association for the Advancement of Science, during its meeting at Cincinnati, May, 1851, which led to a discussion, in which I expressed my conviction, based partly on physiological grounds, and partly on the examination of similar impressions, that they were the tracks of some palæozoic Crustacean, and not those of a Reptile.

these footprints "were not made by a Chelonian Reptile,[1] nor by any vertebrated animal." About the same time, Captain Lambert Brickenden[2] described foot-tracks from the Old red sandstone of Morayshire, which are also ascribed to Chelonians. Though I have not seen these fossil footprints, I have seen the impressions left by Turtles, upon soft mud, often enough to feel justified in saying that the Scotch foot-marks have not the remotest resemblance to the footprints of a Chelonian. These animals, when walking, stretch the legs on opposite sides of the body, in a diagonal position with reference to the body itself, so that the foot-marks of the fore foot of one side and those of the hind foot of the opposite side, form couples which alternate with the corresponding couples arising from the fore foot and the hind foot of the other side. No such succession is observed in the footprints described by Captain Brickenden. No more do the footprints from the Red sandstone near Dumfries, in Scotland, described by Dr. Duncan and by Dr. Buckland, and reproduced by the latter in his Bridgewater Treatise, resemble foot-marks of Turtles.

Long before the publication of these different notices, the existence of Turtles in older geological formations had been asserted by Sedgwick and Murchison,[3] who, upon the authority of Cuvier, had referred to the genus Trionyx a fragment of bone found in Scotland, in the slates of Caithness, which belong to the Old red sandstone formation. These remains I have shown, in my work on Fossil Fishes,[4] to be those of a very remarkable type of extinct Fishes, forming a distinct family, the Cephalaspides, and belonging to the genus Coccosteus. Kutorga has also described fragments of fish bones of the Old red sandstone, as belonging to the family of Trionyx.[5] In his researches on fossil bones, Cuvier, finally, has referred to Chelonians several remains from the Muschelkalk, which were afterwards shown by Herman von Meyer to belong to the genus Nothosaurus.

These are, as far as I know, all the instances in which the existence of Turtles in deposits older than the Jura has been maintained. Though introduced by the highest scientific authorities, there is not one of these alleged cases which stands a careful criticism. Neither the tracks of the Potsdam sandstone of Owen, nor

[1] Description of the Impressions of Footprints of the Protichnitis from the Potsdam Sandstone of Canada, by Professor Owen, Quarterly Journal of the Geological Society of London, 1852, vol. 8, p. 214. The geological description of Sir William Logan, which precedes, p. 199, gives the most minute account of the occurrence of these fossil footprints in Canada.

[2] Quarterly Journal of the Geological Society of London, vol. 8, p. 97.

[3] On the Structure and Relations of the Deposits contained between the Primary Rocks, and the Oolitic Series in North Scotland, by A. Sedgwick and R. I. Murchison, in the Transactions of the Geological Society of London, 2d series, vol. 3.

[4] Monographie des poissons fossiles du vieux Grès Rouge, Neuchâtel, 1844, 1 vol. 4to. p. 22.

[5] See the same Monograph, p. 91. These remains belong to the genus Asterolepis.

those of the Old red of Captain Brickenden, accepted by Lyell and Mantell, nor those of the Rev. Dr. Duncan, examined and described by Dr. Buckland, have the slightest resemblance to the tracks of any living Reptile, while the bones of the Devonian from Caithness, referred to Trionyx by Cuvier, and those of the same formation referred to the same genus by Kutorga, are really Fishes, and those of the Triasic period, described by Cuvier, are Reptiles of another order. The first genuine Testudinata known among the extinct representatives of the class of Reptiles, in past ages, belong to the oolitic series.

It is self-evident, that the geologist who has neither the means nor the inclination to test critically how far any identification of fossils may be relied upon, must, at every step, be led to the strangest conclusions. What would be the direct inference, with respect to the plan of creation, to be drawn from the presence of unmistakable Turtles in the oldest fossiliferous rocks? Of course, the conclusion would be that there is no kind of progressive order in the successive appearance of Vertebrates upon the surface of our earth, since the presence of the highest Reptiles would appear coeval with that of the oldest Fishes. But let it be understood that all the supposed cases of the occurrence of Reptiles prior to the Jura which have been quoted from time to time, cannot be relied upon, and are evidently mistakes, the whole question at once changes its aspect, and we see again an intelligible plan in the order in which organized beings have successively made their appearance upon this globe.

The following diagram, made, so far as it has been in my power, with the same critical method with which I have scrutinized the case of Turtles, may give a more definite idea, not only of the time of the first appearance of Testudinata, but of their relations to their predecessors, their contemporaries, and their successors upon the earth.[1] It shows conclusively, that the four great branches of the animal kingdom have had simultaneously representatives from the very beginning of the existence of organized beings. It shows further, that the law which obtains in the gradation and successive appearance of the Radiata, Mollusca, and Articulata is not the same as that of the Vertebrata. For while the classes of the first three branches appear all at the same time in the lowest fossiliferous rocks, with the sole exception of Insects, there is a decided gradation among the classes of Vertebrata. Among Radiata, we find simultaneously in the lowest rocks, Polypi and Echinoderms. The absence of remains of Acalephs in the oldest rocks is no objection to this assertion, when we remember how soft and

[1] In order to appreciate fully the meaning of this table, it would be well, while considering it in detail, to read section 7 of the first chapter, page 23, and also sections 21–28, from page 93 to 123, where many points are considered, which here are represented graphically. Comp. also Chap. 3, p. 181–187.

perishable their bodies are. The presence of well defined impressions of Medusæ in the lithographic limestone of Solenhofen, specimens of which are preserved in the Museum of Carlsruhe, confirms the assumption that they occur everywhere, where Polypi and Echinoderms are found together. Among Mollusks, Acephala, Gasteropoda, and Cephalopoda are always found in close association. Among Articulata, this is also the case with Worms and Crustacea; Insects only appear at a somewhat later period. Whilst among Vertebrata, we find only Fishes, Selachians, and Ganoids in the lowest formations; next Amphibians, next Reptiles, next Birds, and last, Mammalia.

TABLE,

SHOWING THE PERIOD OF THE FIRST APPEARANCE OF THE TESTUDINATA COMPARED WITH THAT OF THE OTHER ANIMALS.

Geological Periods.	Radiata.			Mollusca.			Articulata.			Vertebrata.							
	Polypi.	Acalephs.	Echinoderms.	Acephala.	Gasteropoda.	Cephalopoda.	Worms.	Crustacea.	Insects.	Myzontes.	Fishes.	Selachians.	Ganoids.	Amphibians.	Reptiles.	Birds.	Mammalia.
Present.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pliocene.	—		—	—	—	—	—	—	—		—	—	—	—	—	—	—
Miocene.	—		—	—	—	—	—	—	—		—	—	—	—	—	—	—
Eocene.	—		—	—	—	—	—	—	—		—	—	—	—	—	—	—
Cretaceous.	—		—	—	—	—	—	—	—		—	—	—	—	—	—	
Jurassic.	—	—	—	—	—	—	—	—	—		—[2]	—	—	—	=[3]		—[5]
Triasic.	—		—	—	—	—	—	—	—			—	—	—	—	—[4]	
Permian.	—		—	—	—	—	—	—	—			—	—	—	—		
Carboniferous.	—		—	—	—	—	—	—	—			—	—	—			
Devonian.	—		—	—	—	—	—	—				—	—				
Silurian.	—		—	—	—	—	—	—				—	—				
Cambrian, or Azoic.[1]																	

[1] The most natural limit between the Cambrian and Silurian periods seems to me to be the horizon at which animals and plants make their first appearance.

The Table renders it unavoidable to refer notes 2, 3, 4, and 5 to the opposite page.

The classes adopted in this table are circumscribed according to the principles discussed in the first part of this work.[6] I have nothing special to add with reference to the classes of Radiata, Mollusks, and Articulata; but it may be proper to state here, that the order of appearance of the classes of Vertebrata makes in favor of the subdivision of the Fishes into four classes. The Selachians, in particular, differ so completely from the ordinary Fishes, that it is surprising they have not long ago been considered as a distinct class.[7] In a palæontological point of view, the early appearance of the Selachians has a deep meaning, when we consider how extensively the characters of the higher classes of Vertebrata (such as their few large eggs, which recall the true Reptiles and the Birds, and the placental connection of the embryo of some of their species, which recalls the Mammalia) are blended in their structure with embryonic features, (such as their cartilaginous skeleton and their branchial fissures,) whilst the Myzontes are purely embryonic. The Ganoids, on the other hand, stand in a special prophetic relation to the Reptiles proper;[8] and their extensive reduction, at the time of the first appearance of the Fishes proper, is truly significant.

[2] The period of the first appearance of genuine Fishes is somewhat doubtful, and depends upon the appreciation of the true relations of the Leptolepids. If they are Ganoids, as I consider them, then the class of Fishes proper does not appear before the Cretaceous period.

[3] This is the period of the first appearance of Testudinata; at a time when neither genuine Birds nor genuine Mammalia existed.

[4] The presence of Birds in the Triasic period is only inferred from the numerous footprints found in the Red sandstone of the valley of the Connecticut, respecting the true characters of which I have expressed my doubts elsewhere. As it is now known that the earliest representatives of higher types often exhibit characters common to them and to lower types, it seems to me probable that the first Birds were not so completely different from the other Vertebrates as the Birds now living are. Before the first appearance of genuine Birds, there may have existed bird-like Vertebrates, combining in their structure Reptilian and Mammalian characters, as we find early Reptiles combining Fish characters, and even anticipating, in some of their features, peculiarities that are afterwards characteristic of Birds and of Mammalia. The foot-marks of the Trias suggest such suppositions much more readily than the idea of a very close affinity to real Birds. For more details upon these tracks, see HITCHCOCK, (ED.,) An Attempt to Discriminate and Describe the Animals that made the Fossil Footmarks of the United States, etc., Mem. Amer. Acad. 1848, vol. iii. p. 128, and DEANE, (JAMES,) Illustrations of Fossil Footprints of the Valley of the Connecticut, Mem. Amer. Acad., 1849, vol. iv., p. 204. No Bird remains are known from the Jura.

[5] The presence, in the Jurassic period, of remains belonging apparently to the class of Mammalia, has long been known. But Owen for the first time set forth their true relations, in a paper published in the Transactions of the Geological Society of London, 2d series, vol. vi. Whether Microlestes of the Trias, described by Plieninger, belongs to the same type, is still questionable. If it is a Didelphian, it would carry this sub-class one period lower down. It is curious, that nothing like them has thus far been found in the Cretaceous formation. So the age of Mammalia proper begins with the Eocene period, unless some recently described Cetaceans truly belong to the Cretaceous period.

[6] See Part I., Ch. 2, p. 145, and Ch. 3, p. 183.

[7] Aristotle alludes here and there to the Selachians in contradistinction to the Fishes proper.

[8] Comp. Part I., p. 116 to 118.

SECTION XVIII.

SUB-ORDERS OF TESTUDINATA.

The Sub-Order of Sea-Turtles — CHELONII, *Opp.*[1] The sea is the home of these animals. They swim freely, and sustain themselves in the water for any length of time without seeking the bottom or the shore for support or rest. They never go on land, except to lay their eggs, and then proceed only a short distance from the shore, moving slowly and in a very constrained way. They swim almost entirely by means of the front limbs; the other pair act independently, and are chiefly useful in aiding to balance the body and guide the general course. The fore-arm and hand form a sort of paddle, or rather a wing. These two wings are raised together, and also strike downward simultaneously; but the blow is not exactly vertical, the wings being carried forward as they rise, and approaching the breast when brought down. They descend farther below the body than they rise above it, and their motion is very similar to that of a Bird's wings; indeed, the animal may be said to fly through the water. On land, these animals still move the front limbs together, carrying them forward, throwing the weight of the body upon the elbows or thereabouts, and then pulling the whole toward them.

The peculiar flying locomotion of this sub-order affects the general symmetry of the body very essentially in two ways: first, it makes it necessary that the bulk of the body should be carried forward near the wings, otherwise the animal could not control it; secondly, the force necessary to propel the wings requires a large muscular apparatus, and this takes much room, so that the fore part of the body (dividing the whole crosswise into two parts of equal lengths) far outweighs the hind part, being in bulk in the proportion of two to one; the fore part is broad and high, the hind part descending and narrowing gradually. The humerus is very short, and the extensive surface of the wing arises principally from the blade, which is formed of the forearm and hand. This blade is long, broad, and thick at the base, thin along the inner margin, and pointed at the outer end; it is turned back at the elbow, and cannot be brought out in a line with the humerus, though it is capable of moving towards it and away from it through a long arc. The force and general direction of the blow is given by the muscles of the shoulder; but the surface presented is determined in a great measure by the rotation at the elbow, at the wrist, and within the hand, the blade being

[1] This sub-order was first recognized and characterized by Oppel, in the work quoted below, p. 309. Compare also Sect. 2, p. 241, where the synonymes of the sub-orders are given, and Pl. I.–VI.

turned, now edgewise, now flatwise, to the resisting medium. The fore-arm is short; the radius is carried down and back under the ulna, and the inner side of the hand carried down with the radius. By this peculiar arrangement, the flat surface of the hand is more directly presented to the resistance of the water in the downward and backward flying blow. The fingers add the greater part to the length of the blade; they are very long, stiff, and fixed in their respective places, their only movement consisting in a slight accommodation to the turning of the whole blade. The muscles and skin form one continuous surface over the fingers, excepting the last joint of one or two of them, which, sometimes at least, protrudes, and has its protruding surface covered with a nail. The coracoid process is very long; the other bones of the shoulder apparatus short and stout. It is necessary to the flying locomotion of this sub-order that the wings should have a free sweep by the front end of the body, and that nothing should hinder them in rising and descending or moving backward and forward; hence the shield cannot project forward above or below, and the humerus carries the elbow, in all its positions, beyond it. Again, as the humerus is so short, and the blade so long, the front limbs cannot be brought round before the body; but, when at rest, the blades hang down, or are placed beside or upon the outer edges. Although the front limbs are the principal locomotive organs, and are essentially wings in all their operations, there is yet one marked structural difference between them and the wings of a Bird; for with the Turtles the humerus reaches forward, and the forearm and hand are turned backward in one line from the elbow, whereas with the Bird, the humerus reaches backward, the forearm forward, and the hand again backward, the main surface of the wing being in the angle of the forearm and hand, instead of being, as in Turtles, in the angle of the humerus and the limb below. The pelvis and hind legs are very small. The legs, as was said above, do not move together with the wings, and they take little part in locomotion beyond aiding to balance and guide the body. The femur and leg are short, and the toes also short, compared with the fingers, but they form the greater part of the whole blade below the knee. The leg and foot are formed into a paddle, much smaller than the blade of the front limbs, and broadest near the outer end. Below the knee, this blade is generally turned backwards; but it moves through a long arc back and forth, and may even be brought out upon a line, or nearly on a line, with the femur. The paddles often strike directly downwards, so that the plastron cannot extend under them, and is very small under the pelvis.

The neck is short and little flexible, so that the head is not withdrawn under the carapace; instead of this, it is protected by a very large development of the post-frontal, parietal, jugal, and mastoid bones, making a bony arch over the whole head back of the eyes, and projecting somewhat over the neck, entirely covering the temporal muscles above. Thus neither head nor limbs can be withdrawn into the shield, and the front limbs cannot even be brought round before the body, but they can all be drawn back somewhat. So the method of protecting the extremities and the head, which is so fully developed in the other sub-order, and is so characteristic of the order, is here but just begun. The shield itself is here much less developed than in the other sub-order. In one family, the Sphargididæ, it is little more than a broad girdle, encircling the thorax and abdomen; its bony part does not rest upon the ribs, and has no marginal rim. In the other family, the Chelonioidæ, the shield is somewhat larger, covering the pelvic region above; but still the front limbs, including the shoulders, are free and exposed, and so also are the hind limbs below, including the hips. Although the bony derm rests upon the ribs, their union never becomes so intimate as in the other sub-order, and the plastron is but imperfectly ossified and rather loosely connected with the carapace. Thus we find the most prominent characteristic features of the order least developed in this sub-order; and if we add to this the habitat, the mode of locomotion, the paddle-like structure of the limbs, the reduced state of the hind pair, the want of specialization in the neck vertebræ, and the unsymmetrical relations of the two ends of the body, we cannot hesitate to consider this group as the lowest of the Turtles, and to recognize a kind of gradation in rank between them and the Amydæ. But here, in this lowest group, where the characters of the order are least prominent, we find features of form and structure which remind us of animals higher in the series, and belonging to another class. The mode of locomotion, the form and structure of the locomotive apparatus, the great preponderance of the fore part of the body, the bill-like jaws, the overlapping of the scales in some, as in Penguins, are all characters which belong to the class of Birds, and are there only carried out to their fullest development.

The Sub-Order of Fresh-water and Land Turtles—AMYDÆ, *Opp.*[1] The habitat is various. Some species spend nearly all their life in the water, some live partly under water and partly on dry land, and some entirely on dry land; yet none are entirely aquatic, none remain for any great length of time in the water without seeking the bottom, nor can they swim unsupported for a long distance. When in the water, they remain usually at the bottom, either at rest or moving along over it. They seldom swim freely, except when they rise to the surface or descend to the bottom. So, in fact, they dwell principally upon land, sometimes under the

[1] Like the sub-order of Chelonii, that of Amydæ also was first recognized and characterized by Oppel, in his classical paper, Die Ordnungen, Familien, u. Gattungen der Reptilien, München, 1811, 1 vol. 4to.

water, and sometimes in the open air. The difference between these two conditions does not acquire much importance with reference to the characters of the sub-order, as will be seen from the fact that, in the family of Emydoidæ, one genus at least never goes into the water, while several genera live the greater part of the time in water, and there is a series of intermediates. These differences affect the structure and symmetry in a smaller degree, and are not to be compared in importance with those which distinguish the sub-orders; they do not essentially alter the mode of progression.

The locomotion is entirely different from that of the sea Turtles. It no longer takes place by a flying, but by a walking motion; the weight is not thrown upon the front limbs, but is almost equally supported by both pairs; the front pair are not carried up together, and then brought down simultaneously, but they alternate with one another, as do also the hind pair; the front legs of one side move with the hind legs of the other side, so that the two pairs act in concert; further, they move back and forth below the carapace, in a diagonal plane between the perpendicular and the horizontal diameter of the body. The two pairs are nearly equally developed, as also are the pelvis, and shoulder apparatus. As the bulk of the body is no longer thrown upon the front limbs, and as the muscular apparatus of the two pairs occupies about equal space, there is no such contrast between the two ends of the body as exists in sea Turtles. This mode of progression, and the consequent symmetry, allow greater development of the bony shield than can take place with the other sub-order. As the fore limbs are not raised high up, when moving, the carapace may be extended forward without interfering, and as they are not brought far down crosswise over the body toward one another, the plastron may be broad between them. The carapace is always broad above the pelvis, and covers all that part of the body, and the hind legs, when they are at rest; the plastron is sometimes broad under the pelvis and the hind legs.

The limbs are never reduced to paddles or wings; the feet are always distinct from the legs; the articulations at the wrist and ankle joints allow distinct movements, and not merely a kind of yielding to the turning of the whole limb, below the elbow, as with the sea Turtles. In the feet of this sub-order, the toes never have the great length which distinguishes them in the wings and paddles of sea Turtles. When the foot is adapted to walking on dry land, the toes are shortened, and the whole concentrated, and their joint with the leg above is rather stiffened; when it is more adapted to swimming, there is greater freedom of motion at the wrists and ankles, and between all the bones of the feet below; the phalanges are prolonged, and the toes joined by a broad web, capable of being spread far apart and closed together. When the blow is struck, a broad, webbed surface is presented to the water, and when the foot is withdrawn for another blow, the web is folded;—a very different way of controlling the surface presented to the resistance of the water from the turning of a stiff blade, now edgewise, now flatwise, which takes place with the sea Turtles. The limbs, thus jointed and proportioned, can always be withdrawn under the carapace, the front pair before, and the hind pair behind, the main bulk of the body; the neck is always retractile enough to allow the head to be withdrawn partially, and generally completely, within the shield; and we nowhere find the temporal muscles protected by such a very broad bony arch as exists in the sea Turtles.

Here, then, those features which are most peculiarly characteristic of the order of Turtles, namely, the protection of the body by the shield, and the withdrawing into the shield of the head and neck, and limbs and tail, are most fully developed. This sub-order occupies clearly a higher rank than the other; the equilibrium of the body, the higher development of the limbs, the coöperation of both pairs in the progression, the greater specialization of the neck vertebræ allowing the head to be withdrawn under the carapace, the nature of the habitat, and the higher degree to which the characters of the order are carried,—all these features assign to the Amydæ a rank superior to that of the sea Turtles. In this higher group, the Bird characters, which are so prominent in the sea Turtles, yield to the characters of a higher class. The equal development of the two pairs of limbs, their full coöperation, the walking locomotion, the elevation of the body free from the ground while walking which takes place with most of them, and the general symmetry of the body, are characters which remind us of the class of Mammals. And the analogy is the more striking when we remember that this is the first instance, in the series of Vertebrata, of real walking, unless the running of some toads be considered as such; for the Salamanders, the Lizards, and the Crocodiles move partly by means of the vertebral column bending and carrying the legs forward, now on one side and now on the other. These Mammalian characters may be not so striking here as the Bird characters are with the other group, for the class of Reptiles is further removed from that of Mammals than the Birds; still the analogy is too complete and too clear to be accidental, or to be passed over in silence. One marked difference between the locomotion of these Turtles and that of Mammals is, that in the former the knee and elbow joints open in the same direction, whereas in Mammals they bend in directions opposite to one another.

The characters of the Chelonii and Amydæ show these two groups to be sub-orders, and neither families nor orders proper, as they partake of the features of orders, without extending to the whole structure of all the different systems of their organization.

SECTION XIX.

CONCLUSIONS.

I have attempted in the preceding sections to illustrate, so far as it was in my power, the characters of the order of Testudinata, more with the view of ascertaining what are ordinal characters, than in the hope of drawing a complete picture of the whole order. Consulting the leading works upon this subject, I have found that all original investigators agree in presenting, as characteristic of this type, the same kind of characters as I have mentioned above, and nearly in the same way, though perhaps they have not aimed so directly, and with the same care, as I have done, at admitting only such anatomical features as are truly characteristic of the whole order, and excluding every feature which occurs in other representatives of the class. If I have succeeded in this attempt, and if the characters presented above are truly those of the order of Testudinata, it follows that ordinal characters are essentially anatomical characters, and not what are commonly called zoölogical characters. They are borrowed from the peculiar complication of the anatomical structure of the class of Reptiles, so that this type furnishes direct evidence of the correctness of the definition of orders given in the first part of this work,[1] where it is stated that orders are natural groups, characterized by the degree of complication of their structure. It follows, therefore, that, to characterize orders correctly, we must compare their anatomical structure with that of the other orders of the same class, as I have done above,[2] and that, by this comparison, we ascertain the relative rank of this kind of natural groups; whereas in characterizing families, we consider the structure with reference to the form of the animal; and in characterizing classes, we illustrate, in a general manner, the ways in which, and the means by which, the plan of their respective branches is executed.

The characters of classes, like those of orders, are anatomical; but in characterizing a class, we consider the nature of the different systems of organs which constitute their living frame, we investigate the relations of their systems of organs to one another, their respective functions, etc., and not the various degrees of complication which they may exhibit in these combinations, for such complications constitute ordinal characters. If this is correct, and true to nature, it follows further, that such a distinction as is often made in Natural History, between

[1] See Part I., Chap. 2, Sect. 3, p. 150.

[2] See Part II., Chap. I., Sect. 3, p. 252.

anatomical and zoölogical characters, is not correct, in the sense in which it is generally understood; but that so-called anatomical characters are either characters of the classes or of the orders, and, to some extent also, of the families, while the so-called zoölogical characters are more properly generic or specific characters, and the features generally considered in what is now called Philosophical Anatomy, and in Morphology, are mostly characters of the great types or branches of the animal kingdom. The separation of Comparative Anatomy from Zoölogy, as a distinct branch of science, is therefore only justifiable in so far as the proper meaning of those peculiarities of the structure of animals which characterize classes or orders, or families or genera, have not yet been satisfactorily ascertained; but I look forward to the time when the more comprehensive groups of the animal kingdom shall be illustrated in our zoölogical works with that fulness of structural illustrations which is now generally supposed to belong to anatomical works only, and with that searching care which alone can insure a proper discrimination between organic features of different kinds.

Such a method will, in due time, relieve our science of all the exaggerations respecting homologies, with which it has of late been incumbered. As soon as it is understood, that the great branches of the animal kingdom are characterized by different plans of structure, and not by peculiar structures, we shall have fewer of those unsuccessful attempts to force every peculiarity of every type into a diagram, by which, renouncing almost entirely the study of the wonderful combinations of thought which are manifested in the endless diversity of living beings, authors substitute for them a dead formula of their own making. Having once understood, for instance, what constitutes the peculiar plan of Vertebrates, we shall be prepared to find it executed in a variety of ways and with innumerable complications, and we shall no longer try to force the framework of a Fish into a Procrustean bed, to which we may reduce at the same time all other Vertebrates, with Man. When the axis of the body consists of a simple dorsal cord, we shall be willing to acknowledge that it is not to be considered as an articulated backbone; when the skull-box consists of a continuous cartilage, that it is not to be artificially divided into isolated parts; and, when there are no limbs at all, we shall not assume that they exist potentially in the same degree of complication as in animals more favorably endowed. And, let it not be supposed, that such a sobriety of views excludes general comparisons; it only withdraws them from the field of fancy to the rich field of life.

Suppose, for a moment, that we should attempt to homologize the different parts of the solid shield of a Turtle with the complicated system of muscles which intervene between the ribs and the skin in the trunk of other Vertebrates, or assume, perhaps, that the few scales which cover their back are to be considered as arising from the confluence of the innumerable hairs or feathers which cover the backs of Birds or Mammalia,—would this not be doing, for the muscular system or for the external coverings, what is now doing, on so broad a scale, for every isolated point of ossification in the skeleton? Let us rather be satisfied to recognize the fact, that Vertebrates have a plan of their own; that this plan is carried out in one way for Fishes, in another for Reptiles, in yet another for Birds, and again in another for Mammalia. It is true, grand traits of resemblance prevail through all, showing that the same thought is variously expressed in these different classes, and that this thought has found utterance in an endless diversity of distinct beings; but this resemblance lies chiefly in the unity of the conception, and not in the similarity of the execution. The various complications introduced in this execution constitute the typical peculiarities of the orders, while the forms in which they are inclosed constitute the typical peculiarities of the families, and the finish of the execution constitutes the typical peculiarities of the genera, while the relations to one another, and to the surrounding world, of the living individuals in which these thoughts are manifested, generation after generation, constitute the typical peculiarities of the species. Then, and then only, shall we grasp at the same time the grandeur of the conception of the plan according to which the animal kingdom is framed without losing sight of the admirable complication of its execution, and the infinite variety of conditions under which life is maintained.

There is hardly any other type in the whole animal kingdom, in which the direct intervention of thought, as the first cause of its characteristic features, can be so fully and so easily illustrated as in the order of Testudinata. In the first place, these animals are so peculiar in their form and in their structure, that they strike, at first sight, every observer as belonging almost to another creation. They have been represented as inverted Vertebrata; and the peculiarity in the position and connection of their limbs has been so magnified, even to the rank of a class character, that very special conditions would seem necessary to their existence; and yet they are so extensively scattered upon the whole surface of the globe, among other animals of entirely different form and structure, upon land, in the fresh waters, and in the ocean, that, unless it can be shown that, besides its known properties, matter possesses also a turtle-making property, it must be granted that there are special thoughts expressed both in their structure and in their forms, and that the plan to which they belong, notwithstanding their striking differences, must have been devised and executed by a thinking being. In the next place, the different representatives of this order are allied to one another in such a manner, that every feature of their organization appears to have been minutely considered; for, while some of their genera are closely linked, and constitute extensive families with numerous species, other families are small, and their representatives more remotely allied and fewer in number; and, while some are limited in their range, others have the widest distribution, so much so indeed, that even those peculiarities of their existence which may seem the most trifling appear to have been devised with the same thoughtfulness and the same providential care as their most important general characteristics. It is, however, in the mode of their embryonic development, that Turtles show, most directly, the thoughtful connection which may be traced among all their peculiarities. For, while the young embryo Turtle exhibits, at some period of its life, the closest resemblance to other Reptiles, and while still younger, even to other Vertebrata, as soon as its Turtle characters begin to appear, nothing can be more surprising, or more attractive to watch, than the manner in which the peculiarities of the Amydæ and Chelonii proper, and those of their different families, are successively blended and specialized in the periodicity of their exhibition, in their prevalence, in their transformation, and in their final growth. It seems almost as if we were allowed to penetrate into the sanctum of the great Artist, and could behold him so combining his thoughts as to produce a variety of master-works, in this case all representing the same idea, but each in a peculiar way, and at last endowing them with life for ages to come.

The nature of these combinations, as characterizing the different families of Testudinata, will be illustrated in the following chapter.

CHAPTER SECOND.

THE FAMILIES OF TESTUDINATA.

SECTION I.

GENERAL REMARKS UPON FAMILIES.

FOR many years past, naturalists have extensively indulged in the practice of separating, as natural divisions, any group of genera, or even single genera, which appeared to differ strikingly from other genera, and of calling such divisions, families, without apparently caring to ascertain upon what characteristics they were founded; nay, frequently without even assigning to them any characters at all, remaining for the most part satisfied with naming such families.[1] It is, however, not enough to select some prominent genus, and give to it a patronymic ending, in order to establish the right of any natural group to be considered as a family. The result of this practice, as it now lies before us, has been to incumber the nomenclature of Zoölogy with innumerable names ending in *idæ* or *inæ*. For, regardless of every question of priority, the names of families and sub-families should end in that way, according to certain writers.

As no advantage can be derived, from such a method, to the real advancement of science, I have proceeded upon an entirely different plan in this work. After a most minute and careful comparison of all the Testudinata I could obtain, and having made myself familiar, as far as I could, with all their features, I have arranged them, according to their different degrees of relationship, into as many natural groups as I could recognize, and then only attempted to find out

[1] Naturalists who in no way deserve this imputation will pardon me if, to avoid useless personalities, I allude to the prevailing evil, without mentioning names. A mere glance at my "Nomenclator Zoologicus" will show to what extent this method of making families has been carried.

what was the real value of all these divisions. Trusting, in a measure, to the principles discussed in the second chapter of the first part of this work, I soon ascertained which of them exhibit generic characters, and which were to be considered as families. I may well add, that I had also the gratification of finding that the natural groups, which I had thus practically circumscribed, afforded new and additional evidence of the correctness of the general principles ascertained before by a more extensive study of other classes. This direct confirmation of the general views there expressed shows plainly that these principles are likely to be of immediate practical use in the special investigation of any type of the animal kingdom, and may particularly assist zoölogists in finding out the prominent characters of any kind of natural groups of animals.

In the following pages, I have attempted to show how, according to these principles, families ought to be characterized. It will be seen, I hope, that, though it is easy to acquire satisfactory evidence that families are distinguished one from the other by distinct forms, it requires the most careful comparison to discover what are the structural elements which constitute these different patterns. And if this be so, it must be obvious, that such investigations necessarily lead to interesting results respecting the meaning of the structural differences which distinguish them. For my own part, I have already satisfied myself that in this way much can be learned of the habits of animals, the mode of life being in direct relation to the form of the animal. More than once already has the direct observation of the habits of our Turtles confirmed what the study of their form had at first only led me to suspect.

The essential elements of the form of Testudinata, as far as the body is concerned, are, first, the curve of the back, following the line of the vertebral column, and its relation to a similar line along the middle of the lower surface; secondly, the outline of the outer edge of the shield, in its relation to the height of the carapace, and the depth of the lower part of the body; thirdly, the connection of the upper and the lower surface of the body, as determined by the lateral curves of the carapace and the plastron; fourthly, the outline of the plastron in connection with the openings through which the head, the limbs, and the tail are protruded between the upper and the lower parts of the shield; fifthly, the relation of the bulk of the body with reference to the longitudinal axis. Next to these elements, the form of the neck and head affords excellent characters, as well as the form of the limbs, the relations of the front and hind pair, the articulation of their joints, and especially the form of the feet, the mode of connection of the toes, and the manner in which they act upon the medium of resistance when the animal is in motion.

It has already been stated above, that though orders form necessarily progressive series as they are characterized by the degrees of complication of their structure, other kinds of groups may stand higher or lower, when compared with one another.[1] This is strikingly the case with the families of Testudinata, between which there is a marked gradation. Their respective standing is even so easily ascertained, that, ever since these animals have been divided into families, all herpetologists have arranged them in the same progressive series, beginning with the marine Turtles as the lowest, and ending with the land Turtles as the highest, while they all assign to the fresh-water Turtles an intermediate position between the two other groups. It is true, as far as the marine Turtles, on one hand, and the land and fresh-water families, on the other hand, are concerned, the relative position of these two groups is determined by structural features, which constitute sub-orders; but the gradation of the families is not limited to the relative standing thus assigned to them, for even the families of the Chelonii, and those of the Amydæ, stand higher or lower among themselves; and within these narrower limits the gradation is no longer determined by the complication of their structure, but chiefly by peculiarities in those features which essentially characterize the families, namely, the forms. Chelonii, compared with Amydæ, have lower forms; the form of the Sphargididæ is made up of elements of an inferior order to that of the Chelonioidæ; the form of the Trionychidæ is simpler in its essential elements than that of the Chelyoidæ, or that of the Chelydroidæ and of the Cinosternoidæ, in which last three families are preserved through life, elements of form which recall the characteristic features of the Chelonii, but which mostly disappear in the first years of life in the Emydoidæ. In many respects the form of the Emydoidæ approximates already that of the Testudinina, to which the highest rank undoubtedly belongs, on account of the higher symmetry of the body.

This progressive series of the families of Testudinata, as far as it is based upon their form, is not inferred simply from a vague estimate of the gradation of these forms, as they appear in the adult, but rests upon a direct comparison of the metamorphoses of the young, all of which undergo most remarkable changes in their form. These changes are the more instructive, as they constitute a connected series, when they are compared at certain stages of the growth in different families, and yet they lead, in the end, in each family, to the development of a typical pattern characteristic of the family. Starting from a common type at an early embryonic period, the form is gradually modified to a certain degree, in one family, before it assumes its typical characters; in another family the same primitive type diverges in another direction, and then assumes

[1] See Part I., Chap. 2, Sect. 3, p. 152–154.

its typical characters; while in a third family the progress leads in a still different direction, and ends in another typical form; etc. And yet, in no one instance, can these characteristic patterns be considered merely as resulting from an arrest in the development of one continuous series. On the contrary, they are evidently modifications of one fundamental idea, expressed in various combinations of forms, which are so linked together, that it is only by an abstraction on our part that their connection may be ascertained, as it is only to an abstract conception that their origin and their combinations can be referred. If this be so, — and the sequel will, I trust, furnish satisfactory evidence that this is the only true view of the case, — it follows, that the different patterns which characterize the different families of Testudinata were devised, as the forms in which the structure of these animals were to be clothed, before they were called into existence. The various relations and the close connection which exist between these forms show further that their combinations were so considered beforehand, that when brought into existence they should constitute not only a regular series, but also a perfect system. In other words, the very outline of these animals, humble and low as they are, proclaims as loudly as the grandest features of nature, the direct intervention of a thinking Mind in their creation.

SECTION II.

THE FAMILY OF SPHARGIDIDÆ.

The genus Sphargis, which alone constitutes this family, is now generally referred to the family of Chelonioidæ by modern herpetologists, though for some time it has been considered as a distinct family[1] by the ablest zoölogists. In a

[1] It is a fact worth noticing, that no modern herpetologist has maintained the family of Sphargididæ, though it was, at first, generally adopted as a natural group. This is, no doubt, owing to the looseness of the views now prevailing respecting classification. In similar cases, the objection is constantly urged, that a distinction is not necessary because the genera are so few. It may be useless, it is true, if it leads to nothing beyond the introduction of a new name into the system; but if the distinction is based upon an accurate knowledge of the real standing of any single species exhibiting genuine family characters, then it must be adopted, not because it may appear convenient, but because it exists in nature. I trust I shall show that this is the case with Sphargis. The first author who distinguished this genus from the other Chelonii, as a family, is J. E. Gray, who calls it Sphargidæ, (Ann. of Philos. 1825,) though I think it ought to be written SPHARGIDIDÆ, in accordance with its etymology. Th. Bell adopted it in 1828, (Zool. Journ. Vol. 3,) and so does Fitzinger in his last work, (Syst. Rept. 1843,) changing, however, the name to DERMATOCHELYDÆ; but since 1844 Gray unites it again with the Chelonioidæ. Canino considers it

theoretical point of view, it is of the utmost importance to know that an isolated genus may constitute a distinct family, because such a fact shows how futile and artificial the efforts of those naturalists must be, who aim at establishing the utmost equality between groups of the same kind. Here we have a natural family, not only with a single genus, but perhaps with a single species, or, at the utmost, numbering two or three species, while there are other families, in which the genera may be counted by tens, and the species by hundreds.

The form of the Sphargididæ may be compared to a flattened cone with angular sides, to which are appended in front a large head with a pair of larger naked paddles, and behind, a smaller pair of very broad rudders.

The body is broadest about the arch of the second pair of ribs, where the carapace and plastron first unite, and narrows gradually from thence backwards to near the arch of the seventh pair of ribs, where the union of the carapace and plastron ends. The portion of the vertebral column which is fixed descends gently from the neck to the sacrum. Thus, that part of the body which is entirely encircled by the shield forms a truncated cone with its base turned forward. This cone is the more symmetrical, because the body is deep below the plane of its outer edge and not so extensively flattened as in most Turtles, but tapering downward, so that the median horizontal flat surface of the plastron is quite small. The shield fits close to the body above and below, and assumes the same conical form. The carapace, after passing over the thoracic and abdominal regions and separating from the plastron, suddenly grows narrow much faster, leaving the hind legs almost entirely exposed, but covering the sacrum with a narrow arch, and coming to a point over the tail. In front also, from its union with the plastron forward, the carapace narrows fast, but its front end is truncated; the margin of the sides and end of this narrowed part, which is turned rather sharply downward, are deeply concave, leaving the shoulders and neck much exposed. The plastron narrows constantly from where it first unites with the carapace to where it again separates from it, then narrowing still faster it comes to a point under the pelvis, leaving the hind legs and tail entirely exposed from below. It reaches forward, between the front limbs, but a short distance, and is there much narrowed; the front end of this narrowed part is nearly straight, but the sides are concave. Thus, the hard dermal shield [1]

a sub-family under the name of SPHARGIDINA (Saggio An. Vert. 1831.) The name of Sphargidæ having the priority as a family name, though it is now rejected by its own author, there arises an interesting question of nomenclature in this case, respecting the authority under which it shall be quoted henceforth. My opinion is, that, in spite of Gray himself, it should be referred to as SPHARGIDIDÆ, *Gray;* notwithstanding even the alteration in the spelling.

[1] See Chap. 1, Sect. 5, p. 263.

is here little more than a broad girdle encircling the thorax and abdomen. The carapace has no sharp distinct marginal rim, but curves round over the outer edge and meets the plastron somewhat under the body; this curved outer edge rises constantly backwards.

The carapace is strengthened by several longitudinal ridges, the most prominent of which is along the middle of the back; it is low and small at the front end, but grows higher and broader backward, until just over the sacrum it includes the whole width of the carapace, thence it lowers to the hind end, making this narrow, unsupported part of the shield much firmer than it would be if it was flat on each side. Beginning at the angle of the truncated front end is another ridge, highest at the front end and diminishing backward, so that near the front end the two together render the top of the body nearly flat; but over the pelvis they change the curve of the surface but little. There are two more pairs of ridges outside, but they are quite small, and the lowest one little more than a row of bony nodules. The dermal shield, as in all Turtles, rests upon the vertebral column of the thoracic and abdominal regions, upon the ribs, upon the isolated true bone above the lower neck vertebræ, and upon the true bones of the sternum. Over all these is wrapped a thick layer of coarse fibrous corium.[1] In the carapace, this fibrous corium is protected and stiffened by an overlying sheet of bony pavement. This pavement[2] nowhere rests upon or touches the true skeleton; it is perfectly continuous, without any other suture than those of its pavement-like structure, and without intervals above the ends of the ribs. This bony sheet curves with the carapace at its lower edge, but does not extend over the plastron. The ridges of the carapace, spoken of above, are made by angles in this sheet, filled up below by an increased thickness of the corium, but the lower surface of the latter has no corresponding depressions. Along each of the ridges is a row of nodules. In the plastron, the thick layer of fibrous corium is not at all protected by a bony sheet, and has no bony derm, excepting some rows of nodules; these rows are somewhat irregular, but there are, in general, five of them, a double one along the middle, and two single ones on each side. The corium is supported on its inner surface by the true bones of the sternum, of which there are four pairs; these are long, narrow, and arranged in a continuous row, encircling the flattened, horizontal surface. The foremost pair meet between the fore legs, and at their meeting are broad and strong; they spread apart backward, and overlap the outside of the second pair; the latter send out a process behind each shoulder; the second and third pairs extend the whole length of that part of the plastron which spreads entirely across the body, and

[1] See Chap. 1, Sect. 4 and 5, p. 256 and 263.

[2] See Chap. 1, Sect. 5, p. 264.

the fourth pair meet at their hind ends under the pelvis. So we have an irregular ellipse of true bone, narrowed backward. This ring does not touch the ribs. The ribs are broad and flat, firmly supported and kept in position by the corium resting upon them. The first pair is free from the second, and so is the tenth from the ninth. The ninth extends back by the side of the pelvis, and thus strengthens the narrow end of the carapace. The specimen examined has only some of the neck vertebræ preserved, among which is the last; this has very little motion at the joint with the first dorsal vertebra. There are no scales on any part of the skin; at least, there are none on the skin of the only genus thus far known to belong to this family.

The skeleton is light; the shield narrow and small in proportion to the size of the animal, and so placed with reference to the limbs as to be as little cumbersome as possible; the surrounding thick layer of corium is filled with fat; the body is rounded, and the wings and paddles are large and free. These characters seem to indicate that the animal travels far and fast. This assumption would certainly be justified, if it can be shown, as I shall attempt to do,[1] that the specimens of Sphargis coriacea, observed in Europe, had travelled across the Atlantic from the coasts of North America.

The head is high, short, and very broad at the hind end. As in the other members of the sub-order of Chelonii, the parietal, postfrontal, jugal, temporal, and mastoid bones are so extended as to form one continuous bony roof over the whole head back of the eyes, protecting the temporal muscles, and projecting somewhat back over the first neck vertebræ. In Sphargididæ the parietal bones are almost exclusively devoted to the formation of that arch, as they enlarge the cavity of the brain-box only by a depression in their thickness, and a sulcus formed by two low ridges, and do not reach down to the floor of the skull, the upper occipital bone extending entirely across the brain-box under them. The temporal bones are small, and reach outward, so as to add rather breadth than length to the bony arch, thus making more room for the temporal muscles. The lower edge of the temporal and jugal bones, at their meeting, is deeply concave, thus allowing a broader attachment of the muscles for the lower jaw, and leaving them here somewhat exposed. The floor of the skull is carried far forward, considerably beyond the end of the roof. The prefrontals do not extend beyond the frontals, but the front edges of both make the front end of the top of the skull; the roof formed by them does not extend more than half way over the nasal cavity. The os quadratum descends low down, and carries the articulation of the jaws far below the general level of the floor of the skull. The outer

[1] See, below, Chap. 3.

surface of the intermaxillaries retreats backward from its upper to its lower edge; their inner edges separate about half way down from the nasal opening, and slant outward to the suture with the maxillaries, so that a deep, angular depression is included by their lower edges; the maxillaries too have a deep depression near the suture with the intermaxillaries, so that near this suture the alveolar margin forms a long, sharp, tooth-like projection. The alveolar margin of the upper jaw is sharp all round, except the lateral notches in front, which have a rounded edge. The horizontal part of the alveolar surface is narrow, forming a mere ridge at the front part, but it grows wider backwards. At the front end it rises steeply and high up. The palatines do not project over the vomer so as to form a broad roof below the palate proper, as in the Chelonioidæ, and on that account the passages from the nasal cavity to the mouth open directly downward. For the same reason, the fleshy part of the tongue, which closes these openings when the animal is breathing, is placed further forward than in the Chelonioidæ. The lower jaw is thin, and its margin sharp; its front end terminates in a sharp, strong, prominent point.

The size is greater than that of any other family of the order. I have seen specimens weighing over a ton. It remains to be ascertained whether this family is carnivorous, as the form of the jaws seems to indicate. Though I have seen several specimens upon the coasts of Florida, I could learn nothing respecting their habits. Like the Chelonioidæ, they lay a large number of eggs, as I infer from the condition of the ovary; but I have never seen mature eggs.

SECTION III.

THE FAMILY OF CHELONIOIDÆ.

The family of Chelonioidæ was first distinguished by J. E. Gray, and has been adopted by all modern herpetologists, though not exactly with the same limits which were first assigned to it, since it is now generally made to embrace also the Sphargididæ.[1] But, as we have already seen that the Sphargididæ constitute a

[1] With this wider extension, the Chelonioidæ of modern writers answer exactly to the sub-order of Chelonii, *Opp.*, or to the family of Carettoides of Fitzinger, (Neue Classif., etc., 1826.) See above, p. 242. But, as characterized here, this family is strictly circumscribed within the same limits which Gray at first assigned to it, (Ann. of Philos., 1825.) It corresponds also exactly to the sub-family Chelonina of Canino, (Sagg. An. Vert. 1831,) and to the genus Caretta of Merrem, which is identical with the genus Chelonia of Wagler, of Duméril and Bibron, and of most modern writers.

distinct family, the limits of the Chelonioidæ are again circumscribed, as they were at first.

The form of the Chelonioidæ is that of a heart flattened on one side, from the broad end of which projects a large head upon a thick neck, and from the widening side of which protrude, in front, a pair of large, flat, wing-like, scaly flappers, and below the narrow part of which hang another pair of broad, short, scaly rudders. As illustrations of the prominent features of this family, see several attitudes of the Loggerhead Turtle in Pl. 6.

The body is not, as in Sphargididæ, broadest about the arch of the second pair of ribs, where the carapace and plastron first meet to encircle it, but continues to widen from the front end to about midway, and thence narrows to a point behind; while the vertebral column descends constantly and gently along the whole thoracic, abdominal, and pelvic regions to the tail. The carapace is a roof slanting down on either side from the vertebral column, and thus it continues over the pelvis as well as along the thoracic and abdominal regions, and terminates behind the sacrum, by the meeting at a point of the outer edges and the middle line; the only deviation of its outline in passing from the abdominal to the pelvic region being a slight elevation of the lower edge above the hind legs. The carapace is bordered all round by a distinct marginal rim; about the front end this rim is turned downwards, but shortly behind the beginning of the union with the plastron it flares outward, and so continues to the hind end. In consequence of this peculiar form of the marginal rim, the shoulders are much more protected than in the Sphargididæ; its width adds still more to the protection of the hind limbs. The plastron is joined to the carapace from near the arch of the second to between the arches of the sixth and seventh pairs of ribs. The plastron and the carapace meet at a sharp angle, the plastron descending but little below the level of the outer edges. The plastron, like the carapace, grows broad to about midway of the body, and narrows thence backward; it underlies a very large part of the lower surface. The opening about its hind end, for the protrusion of the limbs and tail, is smaller and more under the body than in the Sphargididæ. Thus the shield, — instead of having, as in Sphargididæ, a conical form wrapped closely around the thorax and abdomen, and growing narrow backward in passing over those regions, then narrowing still much faster to pass over the pelvis, — presents here an extended roof-like carapace, with the outer edge sharply defined, flattened upon the sides, broadest about midway, protecting above the whole body from one end to the other, and a plastron which descends but little below the outer edges.

The shield, having a form widely different from that of the Shargididæ, needs also a different structure and different means of support. Instead of a continuous layer of fibrous corium protected above by a thin bony sheet, we have here both carapace and plastron composed chiefly of bony plates resting immediately upon, and firmly fixed to the true skeleton, and united to one another. The only part of the carapace which remains unossified up to adult age is a narrow strip along the ribs near their lower ends, just above the ossified marginal rim, and extending all round except at each end, where a bony plate is interposed. All the ribs, except the first and tenth, reach down to the marginal rim. The eight other ribs have each a bony plate extending from the inner end outward; but these bony plates do not reach the bony marginal rim, or if at all, not till late in life. The first rib rests on the same plate with the second, and so also the tenth with the ninth. Between the inner ends of each pair of costal plates, above the vertebral column, and firmly fixed to it, there is a small plate filling the whole space; the number of these plates varies somewhat, as one or more of the hinder ones is often divided. In front, an odd plate extends from the foremost plate of the vertebral row, and from between the foremost pair of costals to the front end of the carapace, thus entering into the marginal rim, and connecting it with the bony derm above. This plate does not touch immediately any rib or vertebra, but is connected with the isolated true bone situated above the lower neck vertebræ, and the connection is so intimate that they can hardly be distinguished apart. The ninth pair of ribs reaches almost directly backward, passing over the iliac bones, and giving support to the narrow, pointed hind end of the body. Wedged between the plates which are fixed to these ribs, and behind the last of the plates which are fixed to the vertebræ, there is one lying over the sacrum, but free from it; sutured to this there is another behind, and sutured to the latter still another, which last enters into the marginal rim and terminates it behind. The plates of the marginal rim are in one continuous row all round, consisting generally of eleven pairs[1] besides the odd one at each end; two of these pairs are in advance of the first costals. The costal plates are firmly fixed to the ribs and sutured to one another, and those of the vertebral row are firmly united to one another and to the costals, and those which are fixed to the vertebræ are firmly soldered to them; the marginal plates, passing along the ends of the ribs, connect them with one another, and they are themselves connected with the bony derm above by the odd plates at the ends of the carapace. Thus we have a combination of bony derm with the vertebræ and ribs which is well adapted to give strength and stability to the broad, roof-like carapace.

The plastron is connected with the carapace at the lower edge of the marginal rim by unossified corium, and is somewhat movable or rather yielding there, as it also is along its middle line for the greater part of its length. In Sphar-

[1] The scales which cover these plates are not so constant.

gididæ, the plastron narrows continually backward from where it is first joined to the carapace; it is firmly wedged in between the curved edges of the carapace, and consists of a thick, stiff sheet of unossified fibrous corium, and strengthened only by a ring of bones of the true skeleton. In Chelonioidæ, however, as the plastron spreads out broader at the middle, as it meets the carapace at a sharp angle, as it is connected with it by flexible corium, and as it is somewhat flexible within itself, it also needs a different structure. It is made up partly of unossified corium, and partly of plates composed of true bone and of bony derm. These plates form by far the larger part of the whole, and sometimes nearly the whole plastron. The two kinds of bone are so united as to be hardly distinguishable; we shall therefore speak of the plates without reference to their composition. There are nine of them, four pairs and one odd one. The first pair is situated between the front limbs; they meet in front and spread apart backward, and overlap the outside of the front edges of the next pair, which are here turned forward; at their ends, where they meet, they are broad and strong, but grow slender backward. Joined to the hind edges of this pair, and reaching back somewhat between the inner edges of the second pair, is the odd plate; it is interposed against the front pair at their union, and prevents the formation of a hinge in that end of the plastron. These three plates, thus united, make a broad, firm support for the shoulder apparatus. The second and third pairs reach across from one edge of the carapace to the other. These two pairs are sutured to one another, and together they make up much the largest part of the plastron; their outer edges are connected with the marginal rim by unossified corium, and their inner edges with one another in the same way, but they approach the marginal rim and one another by spine-like processes reaching out from near the fore end of the second and the hind end of the third pair. The fourth pair underlie the pelvis and meet behind it; they are long and slender, extending more backward than inward, and are joined, before, to the third pair.

In this family, then, the dermal shield is much more extended and more bony than in the Sphargididæ; the wings and paddles are more covered by the shield and less free, and the body is more flattened upon the sides and below. These characters seem to indicate that the animal is less capable of powerful and long-continued flight.

The shield is everywhere covered with epidermal scales. These scales are largest upon the carapace, where there is one median row along the vertebral column, and one on each side above the costal plates, besides the row which protects the marginal rim; the foremost of these is an odd, short, but very broad scale; the hindmost, on the contrary, form one pair. Upon the plastron there is a double row of larger scales in the middle, and a row of smaller ones on each side upon its junction with the carapace. On the free skin, the epidermis is also formed into a kind of scales; but upon the wings and paddles the scales become stiff and hard, and they are larger along their inner and outer edges, as they are also where the skin fits close to the bones of the head. The scales on the inner edge of the paddles recall the large feathers of the wings of birds by their arrangement and their elongated form. The central scale upon the skull is the largest. The horny sheath of the bill is very strong.

As in Sphargididæ, the jugal, parietal, postfrontal, temporal, and mastoid bones of the Chelonioidæ unite to make a bony covering over the whole head back of the eyes, protecting the temporal muscles and the brain-box, and projecting even back over the first neck vertebræ; but here the parietal bones are not so exclusively devoted to this office as in the Sphargididæ, for they reach down to the floor of the skull, and add to the length of the brain-box in front. The temporal bones do not, as in the Sphargididæ, add to the width of the head, but reach directly forward and so bring the bony arch further down over the attachment of the temporal muscles to the lower jaw. The prefrontals meet before the frontals, and so carry the top of the skull further over the nasal region. The alveolar margin of the upper jaw has not the deep depressions or the sharp, tooth-like projections observed in Shargididæ. The horizontal alveolar surface is very broad all round the upper jaw, and the palatines project inward from the suture with the maxillaries, uniting, together with the end of the vomer and the alveolar surface, to make a very broad roof below the palate proper. The passages from the nasal cavity necessarily descend very obliquely over this roof, to open into the mouth behind it. The lower jaw is very thick, especially at the symphysis, and its alveolar surface is broad. The neck moves somewhat up and down upon the first dorsal vertebra, and the head may be drawn back so as to reach the carapace, but it cannot be withdrawn under it.

The size of the members of this family is very great, much greater than the average size of the Amydæ, though they do not grow so large as the Sphargididæ. The food of most of them is known to consist of aquatic plants, seaweeds, and the like. Like all the herbivorous animals, the Chelonioidæ are shy and inoffensive; they do not bite, even when hard pressed, but strike with their powerful flappers, and try to make their escape by increased speed. The North American Chelonioidæ lay their eggs towards the end of May or in the beginning of June. They lay a large number of them, about one hundred at a time, and even more, which they deposit on shore, in the dry sand. These eggs are not very large in comparison to the size of the animal, and not perfectly spherical, their orbicular outline being more or less irregular. I have no reason to trust the reports that they lay eggs more than once in a year.

SECTION IV.

THE FAMILY OF TRIONYCHIDÆ.

This family was first distinguished by J. E. Gray, and afterwards adopted by Bell, Fitzinger, Wiegman, Canino, and Duméril and Bibron, while Wagler unites it with the other fresh-water Turtles.[1]

The form of the Trionychidæ resembles a flat orbicular disc, slightly elongated, with a long, pointed head projecting upon a long, slender neck, and two pairs of limbs, one before and the other behind, with broad, webbed feet moving horizontally.

The body is low, flattened, and spread out wide. The upper surface nowhere arches high above the outer edge, either crosswise or lengthwise. The middle line above, along the dorsal vertebral column, or rather the cord of its slightly curved arc, is very nearly parallel to the flat lower surface upon which the body rests. From this middle line the upper surface descends slowly on either side toward the outer edge, lowest about the shoulders in the arch of the third pair of ribs, less and less backward, until over the pelvic region the arch is very slight. As this line is parallel to the base upon which the body rests, the outer edge of the shield rises as the upper surface flattens, that is, from the shoulders backward. At the shoulders it is but little above the flattened part of the lower surface, so that there the bulk of the body is above the plastron and within the arch of the carapace, while at the hind end it is below the carapace and within the inverted arch of the plastron. The opening in the shield for the protrusion of the limbs and tail about the hind end is as high or higher than that about the front end for the protrusion of the head and front limbs. The body is bluntly curved about the front end; it is much broader across the shoulders than across the pelvis, and more pointed behind than before, but the projection of the marginal rim beyond the body gives very different proportions to the carapace. This rim pro-

[1] This family corresponds exactly to the genus Trionyx of Géoffroy, from which its present name is derived. Gray writes the family name Trionicidæ, (Ann. Phil. 1825,) and Trionycidæ, (Cat. Brit. Mus. 1844;) as also does Canino, (Saggio An. Vert. 1831.) Bell writes it Trionichidæ, (Zool. Jour. 1828.) Fitzinger has it Trionychoidea, (Neue Classif. 1826.) Wiegmann changed the name to Chilotæ, (Handb. Zool. 1832.) Duméril and Bibron introduced a third name for this same family, calling it Potamides, (Erpét. génér. 1835.) The name borrowed from the genus Trionyx, having the priority over those of Duméril and Bibron, and of Wiegmann, must be retained; but it must be spelled TRIONYCHIDÆ.

jects very little, if at all, immediately about the front end; but, beginning at the arch of the third pair of ribs, where the carapace and plastron first meet, it grows wider and wider backward, until about the hind end it becomes a broad leaf, which, when the animal is at rest, in the American species at least, drops down behind the body on account of its own weight.

The carapace and plastron first meet in the arch of the third pair of ribs, there encircling the shoulders, and continue to encircle the body from thence to between the arches of the fifth and sixth pairs. The plastron, like the carapace, reaches in front to the end of the body, and no further; after separating from the carapace it extends back under the pelvis, and in Trionyx proper[1] underlies the hind legs, but is there unossified. At the front end, in the American species at least, the shield is flexible above and below, and under the control of muscles. The two margins may even be brought together so as to close entirely the front end of the body, including the head and the greater part of the front limbs.

The shield is by no means entirely ossified; and, where the ossification exists, it is irregular, and less intimately connected with the true skeleton than in the other families of the sub-order. In the adult animal, a continuous area of the carapace, which overlies the greater part of the viscera of the body, is ossified, and extends over the vertebral column, from the neck to the sacrum, and far down on the ribs toward their outer end. This bony derm is divided into plates, which correspond more or less regularly to the bones of the true skeleton, to which they are fixed. The isolated odd plate of true bone is constant, and stretches, with the bony derm, across the front end of the shield from one to the other of the second pair of ribs, over the last vertebræ of the back and the first of the neck. From this plate the vertebral row extends back quite regularly over five or six vertebræ, or even to the hind end of the carapace, but sometimes several of the hinder ones are divided, and sometimes one, two, or three of them are wanting, so that the last two or three pairs of costals meet at their inner ends. The eight pairs of costal plates are pretty constant, but the last pair is not always entirely or even at all separated from the one next before it. All around and outside of this region of bony derm, the carapace is either entirely unossified or has only a narrow border of bony derm at the ends. So the marginal rim cannot be accurately distinguished from the carapace proper, at least not by sutured plates. The plastron is fixed on either side to the leathery border of the carapace. Its framework of true bones consists of four pairs and an odd bone. Two pairs, the second and third, reach from the carapace inward, but do not meet, or if at all, not

[1] Trionyx, in contradistinction to Aspidonectes, corresponds to the genus Cryptopus of Duméril and Bibron, (Erpét. génér., 1835,) or to Emyda of J. E. Gray, (Cat. Brit. Mus., 1844.)

till late in life. The fourth pair extend backward under the pelvis; their front edges extend pretty directly inward, their hind edges more backward, so that they are broad where they meet under the pelvis. The odd bone is long and slender, and arches forward and overlaps the second pair. The bones of the first pair are small, and bent nearly to a right angle; one of their limbs rests against the odd bone, while the other reaches almost directly forward. A thick derm underlies all this bony framework, and spreads out before it, under the shoulders, as far as the end of the body, and, in Trionyx proper, behind it, under the hind legs. A considerable portion of this derm, on and immediately around the bony frame, is ossified; but the larger part, including a space in the middle, is not. There is, on that account, some mobility in the plastron, so that when the animal takes breath it yields and expands. The microscopic structure of the unossified derm has already been illustrated above.[1]

As stated before, the ossification of the shield is very irregular, as it undergoes a great variety of changes during its growth. There is, however, a regular alternation between its growth and that of the true skeleton, with which it is connected, now the one advancing,[2] now the other. The ossification is much less fixed and determined, both as to extent and position, than in the other families of the sub-order. These peculiarities, and their relation to the general form, are still subjects of investigation, and consequently their value as family characters is not fully determined. This much however is certain, that the ossification goes on more slowly, is not carried so far, is much less intimately connected with the true skeleton, and is more varying, than in the other families of the sub-order.

As shown above, the vertebral column is nearly at the same level in the sacral region as within the scapular arch. The pelvis and shoulder apparatus have nearly the same height; they take the proportions of a cross section of the body, that is, they are low and wide spread. The scapula is long, as also are the coracoid and the acromion; but the scapula reaches far outward, and the acromion from thence inward, so that the arch is stretched out, as it were, sidewise, and the shoulder joints are carried close to the edges of the body. The sacrum is broad, the iliac bones are nearly parallel, and the pelvis is as broad across the hip joints

[1] See Chap. 1, Sect. 5, p. 263.

[2] The regular alternation which is observed in the increase and enlargement of the bony derm and of the true skeleton, especially at the ends of the ribs, is an additional proof that the shield is not to be considered as formed by a dilatation of the ribs only, but chiefly by the ossification of the derm. The differences noticed by Owen, in his paper on the fossil Trionyx, (Transact. Palæont. Society, 1849,) as far as they relate to the extension of the ribs beyond the solid carapace and to the form of its rim, are not specific, but may be observed in a series of specimens of the same species, in different stages of ossification. I have satisfied myself of this by a careful comparison of fourteen skeletons of Aspidonectes spinifer, and muticus, of all ages.

as across the sacrum. The ischium is small, the pubis broad and flat; neither extends downward to any considerable distance from the hip joints. The feet are very large, and longer than that part of the legs which extends between the knees and elbows, and the joints of the wrist and the ankle. The toes are long, united by a web, and capable of being widely spread; the inner one is the stoutest, and from thence outward the others are more and more slender, so that the last two, and especially the last one, can serve for little else than to stretch the web; the middle one is the longest, and on either side of it the others grow shorter; the first, second, and third, in the genera examined,[1] have strong nails, the others none. The inner side of the feet and legs is thick, but from the outer side a broad web reaches out and adds much to the surface presented to the resistance of the water in swimming. The skin is not very closely attached to the legs, and hardly surrounds the front ones at all above the elbows.

The neck is very long and flexible. The head too is long, and terminated by a long, leathery snout. The brain-box forms a marked angle with the front part of the head, which is distinctly bent downward. The upper surface of the skull, after passing over the brain, turns steeply downward; the lower surface rises from its hind end to the front end of the brain-box, and falls thence forward, but not as steeply as the upper surface. The lower jaw grows more flattened toward the front end. The sides of the front part of the head approach each other forward, as in all the other representatives of the order. So the whole front part of the head, including the lower jaw, tapers to the projecting leathery snout. The mastoids are long, conical, narrow, from the brain-box outward, and taper backward to a point. The opening to the ear cavity is elongated lengthwise of the brain-box. The temporal arch is narrow, flat, and thin, and not far removed from the brain-box, so that the passage within it for the temporal muscle is small. The arch, from the top of the skull down to the maxillary, is also narrow, and brought near the brain-box. The parietals project very little or not at all outward. Thus the temporal muscle has a slight, narrow, bony covering. The pterygoids are broad, and have but slight depressions on their outer edges. The sphenoid reaches forward between the pterygoids to the palatines. The openings in the palate, by which the mouth communicates obliquely with the nasal cavity, are large, and extend far back; the corresponding openings in the back wall of the nasal cavity are also large, and the foramen olfactorium is large. There is in the skull an opening also in front of the vomer, just within and behind the curved end of the alveolar surface; but, in life, this opening is filled with a fleshy cushion.

[1] These details are truly family characters, as they determine the form of the feet.

The free skin is loose about the neck and limbs. There are no epidermal scales, excepting a few narrow, long ones on the limbs, which serve not so much for protection as to stiffen the web.

The principal habitat of the members of this family is the muddy bottom of shallow waters. They bury themselves in the soft mud, leaving only the head, or a small part of it, exposed. They take breath from time to time, without moving the body, by raising up the long neck and head and carrying the leathery snout above water. They sometimes stay under water a long time, without taking breath; in one instance, a specimen has been seen to remain under water for more than half an hour without raising its snout above the surface. The nature of the habitat is clearly connected with some of the prominent family characteristics. For instance, the buried body needs not the protection of the fully ossified shield which the other families have: the long neck and head, the projecting snout, and the free communication between the nasal openings and the mouth are all connected with the manner of taking breath. These animals rarely go on dry land, and when they do, their locomotion is laborious and constrained; yet it is identical with that of the other Amydæ in the alternation of the limbs of the two sides of the body. When moving through the water, they strike horizontally with both pairs of limbs,[1] alternating however between the right and left foot of each pair; but when they start suddenly, the front limbs are seen moving together towards the tip of the snout, and then striking simultaneously backward with great power to propel the body forward. As the shoulders are placed so near the edge of the body, and the shield does not project free about the front end, the front limbs move mostly beyond the shield, in front and at the sides; and as the outer edge is sharp, and the feet are broad, their web reaches above as well as below the plane of that edge, and when they strike, they drive the water back, partly over and partly under it. The hind legs move back and forth below the carapace and drive the water backward without hinderance, for the flexible broad rim is so light in the water that it yields readily to the current. When these animals move along on the bottom, the limbs still move horizontally, the web striking against the water, and the inner toes against the bottom. They also burrow horizontally, going under the mud only to the depth of a thin layer. When burrowing, they carry the hind feet forward and outward, and thus bracing themselves, press the body forward, digging a part of the mud with the fore feet, and raising a part of it up on the body; the mud is loosened by the strong

[1] All the figures which I know, representing members of this family, are very incorrect. The feet are never brought down, as in other Amydæ, below the level of the lower surface of the body, as they are represented in all the figures of Trionychidæ thus far published.

inner toes, but the whole foot aids in removing it. In walking on dry land, the legs move as nearly horizontally in propelling the body forward as is consistent with the resistance offered by the ground. The animal readily resorts to the shield for protection. The neck and head are withdrawn entirely within the shield, the skin rolling off from the greater part of the neck, and allowing it to protrude naked among the viscera. The legs are withdrawn horizontally, and the skin slips off so far that it does not surround them, except below the knees and elbows. When thus withdrawn, the humerus is carried round into or before the wide spread scapular arch, the elbow being placed very near the head or neck; the fore leg and foot are turned back upon the humerus, the flat surface of the foot being nearly horizontal, so that its outer edge rests against the humerus. The knee is carried almost directly forward, the fore leg turned backward against the femur, and the foot again turned somewhat forward, its flat surface being nearly horizontal. See Pl. 6.

It is easy to perceive the close relations which exist, in this family, between the mode of locomotion, the movements and position of the limbs, and the general form of the body. The limbs, for example, move and are withdrawn horizontally; so also is the body widely stretched out horizontally, and moreover it is flat and low. The flat front end offers little resistance to the water before it; its sharp outer edge offers as little resistance also to the water which is driven back by the fore feet. Again, this low end is well adapted to entering the mud, and the fore feet to loosen and remove as much of it as is necessary to enable them to bury themselves in the soft ground. The flattening of the carapace backward is necessary to allow free horizontal movement to the hind legs.

The habits of the Trionychidæ are little known. In confinement, they exhibit great quickness in their motions, which are abrupt and unsteady, except when they swim rapidly in one direction. They then dart their long, slender neck quickly forward or sideways and upwards, as the Snakes do, and bite in the same way, striking suddenly the objects they aim at. Different attitudes of the North American species are represented in Pl. 6. They feed upon shells, especially upon Anodontas and Paludinas, fragments of which I have frequently found among their fæces and in their intestine. They probably grope for them in the mud with their proboscis. They lay from twelve to twenty and more eggs, of a spherical form, and about the size of a musket ball, which they deposit on shore in the sand near the water's edge. The shell of these eggs is thick but very brittle. The eggs of the Trionychidæ and those of the Cinosternoidæ are the only Turtles' eggs I know, the shell of which is not more or less flexible.

SECTION V.

FAMILY OF CHELYOIDÆ.

The family of Chelyoidæ, as characterized below, embraces only one genus, the Chelys of South America. As limited by former observers, the type of Pleurodères, to which Chelys belongs, combines features which are parallel to those that characterize the families of Trionychidæ, Chelydroidæ, Cinosternoidæ, and Emydoidæ. These peculiarities would seem to be remarkably blended here, if this type were to constitute a single family. I believe, however, that this is not the case.[1] I have, at least, satisfied myself already, that the Chelyoidæ are very different from the other Pleurodères, as the following description may show.

The dorsal part of the vertebral column, from the first dorsal vertebra back-

[1] Of all the types of Testudinata, that of Chelydina is the only one, for the examination of which I have not been able to secure ample materials. Having however myself, when student in the University of Münich, made most of the skeletons which are figured in the Atlas to Wagler's Natür. System Amphibien, 1830, I have derived sufficient information from his illustrations of this subject to satisfy myself that several families are still included under the group called Elodites Pleurodères, by Duméril and Bibron, (Erpét. génér., 1835.) The first allusion to the propriety of considering them as a distinct group may be found in J. E. Gray's Synopsis of the Genera of Reptiles, (Ann. of Philos., 1825,) where they are enumerated as a sub-family of the Emydoidæ, under the name of Chelidina. Soon afterwards Fitzinger considered them as a distinct family, under the name of Chelydoidea, (Neue Classif., 1826.) This family was afterwards adopted by Wiegmann, under the name Chelydæ, (Handb. d. Zool., 1832,) then subdivided into two sub-families by Canino, under the names of Hydraspidina and Chelina, (Cheloniorum, Tab. Anal., 1836.) These two divisions are considered as families by Fitzinger, in his latest work, (Syst. Amph., 1843,) under the names of Hydraspides and Chelydæ. Gray, however, considers them still as one family, under the name of Chelididæ, (Cat. Brit. Mus., 1844.) I hold that the separation of the Chelyoidæ from the Hydraspides, as a distinct family, is founded in nature. From the examination of several specimens in the Museum of the Essex Institute in Salem, I have satisfied myself that the genus Chelys of Duméril truly constitutes of itself a natural family. But I am by no means convinced that the genera referred to the family of Hydraspides are so closely allied to one another as to form one natural family. There are those among them which recall the Cinosternoids, while others resemble more the Emydoids. I am, therefore, inclined to believe, though I have not the means to show, that as Chelys constitutes a natural family among the Pleurodères, analogous to the Chelydroidæ among the Cryptodères, so does Sternothærus correspond to the Cinosternoids, while the other genera correspond to the bulk of the Emydoids, thus forming two natural families, which may be called Sternothæroidæ and Hydraspides. It may be, however, that several of the genera of the Hydraspides differ still more from the others than the sub-families of Emydoidæ among themselves, as, for instance, Podocnemis and Chelodina. This type of Pleurodères requires yet to be thoroughly studied, in all its ramifications, and minutely compared with the corresponding types of Cryptodères, characterized in the following pages as distinct families.

ward, is straight, and parallel to the flattened part of the lower surface. The spinous apophyses of the back are very long; longest about midway of the body, a little shorter toward the neck, and shortest at the meeting with the sacrum. Thus the median longitudinal line of the upper surface is high above the column; it arches from end to end, descending much lower behind than before; it reaches far forward over the neck.[1] The upper surface is broad, bluntly curved at the front end, and narrower and more pointed behind; it reaches far forward in front of the arch of the first and second pairs of ribs, but arches little from side to side, and the bulk of the body is below the outer edge; it is depressed on either side of the middle longitudinal line, along where the ribs first meet it in passing out from the vertebræ. The outer edge is high above the base upon which the body rests; it falls from the front end to about midway, then rises over the hind legs, and again falls behind the pelvis, where it is lowest. The flattened lower surface is long and rather broad; it reaches forward somewhat farther than the upper surface, and backward to the hind edge of the pelvis; it is broadest nearly under the third pair of ribs, where it has about half the width of the body; it narrows but little forward, having a blunt, broad front end, but backward it narrows faster, and at its hind end has about the same width as the pelvis; it rises somewhat from the region where it is broadest to the front end.

It is important to notice, that both the upper and the lower surface extend far in front of the first vertebra of the back, and thus a large part (more than a third) of the neck is inclosed within the walls of the body. The carapace and plastron are joined from the arch of the second to that of the fifth pair of ribs. The bridge on each side, reaching down from the outer edge to the flattened lower surface, is necessarily long, and the openings about the ends of the body for the protrusion of the head and limbs and tail are high and large. The bridges reach considerably inward in descending; their free edges are turned far into the body, and the upper edge is united by long sutures with the second and fifth ribs. The plastron underlies the whole broad flattened lower surface of the body; its free edges project little beyond their attachment, in fact not at all, except about the front end, so that the plastron does not protect, as is the case in the Emydoidæ, any extensive part of the lower surface beyond that to which it is actually attached. The free edges of the carapace project rather widely over the legs, but little behind the pelvis, and only slightly over the neck.

[1] The effects produced in the outline of the outer surface by the varying thickness of the derm are omitted here, and noted below in the description of the shield, as they do not constitute an essential element of the form, but are rather an incidental structural result of it.

The curve from side to side of the outer surface of the carapace is interrupted by three ridges, formed by the increased thickness of the derm, besides the depressions spoken of above, which enter into the form of the body itself. The middle ridge passes along over the vertebral column; it is slight at the front end of the shield, broadest above the first two or three dorsal vertebræ, higher and narrower backward above the sacrum, and then decreases to the hind end of the shield; it occupies the space between the depressions already mentioned. The other ridges are smaller, and situated just outside of these depressions.

The shield is thick, completely ossified, and regularly divided into plates. Besides the eleven pairs of marginal plates and the eight pairs of costals, the usual plates of the vertebral row, with the odd plates at each end terminating the marginal rim, are constant in the carapace. The odd plate and the other marginal plates in front, as well as the first pair of costals, are very large, and give the unusual length and breadth to the carapace in front of the first costal arch.

The plastron is made up of nine plates, as usually, four pairs and one odd one. The second and third pairs reach entirely across, unite with the carapace on each side, and form the bridges and the greater part of the flattened portion of the plastron. The first pair meet in front, and are united by a bony suture, and, reaching backward more than outward, are joined to the second pair by sutures of about the same length. These and the odd plate are large, and give the unusual size to the front part of the plastron. The fourth pair is the smallest, and just underlies the pelvis.

The scapular arch, down to the shoulder joints, is nearly perpendicular. The iliac bones are nearly perpendicular and parallel; their upper ends are very large, and are firmly sutured to the shield above. The ischium too is sutured to the shield below, as also is the pubis. Thus the pelvis is firmly fixed to the shield above and below. This support, together with that of the strong bridges, the thickness of the bony derm generally, and the additional ridges of the carapace, make the shield very firm, in spite of the rather slight curvature of the carapace from side to side.

The ribs extend far out from the vertebræ before meeting the shield, and the space above them on either side of the spinous apophyses is wide as well as high, and affords place for the passage and attachment of very large muscles.

The first dorsal vertebra is turned down at the front end, and its body is much enlarged, so as to present a large, round, articulating surface. Its articulating processes, instead of reaching as usually outward and downward, are placed higher up, near together, and make, with the body of the vertebra, a long, perpendicular axis, upon which the adjoining neck vertebra swings freely from side to side, and but little up and down. This is the prevailing direction of the axis through the neck; but approaching the head there is more freedom of movement up and down, and the head itself turns freely in both planes on the nearest two joints. So the general direction of the bending of the neck is sidewise, and when the animal resorts to the shield for protection, it turns the head to one side,[1] and does not carry it directly back, bending the neck under the dorsal column, as is the usual way. The unusual length of the dorsal spinous apophyses, and the long extension of the bony walls of the body in front of the dorsal column and of the first costal arch, clearly depend upon the habit of these Turtles of bending the neck sidewise. The arch of the atlas is firmly fixed to its body; it is also firmly fixed to the body of the epistropheus, and closes over it, so that this one arch with two vertebral bodies acts fully as one vertebra, which articulates as such with the occipital condyle, and the vertebra next behind.

The head is broad across the ears, low at the hind end of the brain-box, and almost flat in front of it. The middle of the floor of the skull, from the occipital condyle to the alveolar surface, is almost straight. The walls of the ear cavities, as they open from the brain-box, reach far forward and downward, and a line across the middle of the outer ends of these cavities would pass nearly over the middle of the brain-box. The brain-box is very low; the lateral occipitals meet over it, and the occipital crest raises the parietals up some distance, but they fall fast forward, and at their front ends the roof and floor of the skull are brought together, leaving the passage from the brain cavity forward, and the open space on each side, very small and low; the roof is raised a little in passing forward over the cavities of the eyes and of the nose. The eyes are placed far forward, and look upward as well as outward. The jugals and postfrontals are broad behind the eyes, and lie for the most part immediately upon the pterygoids and palatines. There is no arch from the ear region forward, but instead there is one over the temporal muscles, formed by the meeting of the mastoids and parietals. The front wall of the ear cavity curves sharply forward. There is a deep, large depression in the mastoid behind the os tympani for the passage and attachment of the digastric muscle. The roof of the mouth is very broad: the pterygoids have no depression in their outer edges; they turn down on the os tympani, reaching as low as the articulating surface, so that there the roof of the mouth is a flattened arch, but at the front end it is curved up toward the outer edges.

The upper alveolar surface is merely a slight depression in the thickness of the jaw. The floor of the nasal cavity projects forward beyond that surface.

[1] All the fresh-water Turtles which have this structure of the neck have been united by Duméril and Bibron into one group, under the name of Pleurodères, as a sub-family of the Elodites.

In the fresh state, this cavity is prolonged by a membranous snout, as in Trionyx. The lower jaw is thin, excepting at the condyles, where it is thickened on the inner side to a nearly spherical form; the articulating ball projects somewhat higher than the upper edge, but it is lower than the lower edge of the jaw just before it; it rolls by a broad and long convex surface on the articulating surface above. The jaw rises forward to the coronal angle, where it is so high and broad that its upper edge rises above the top of that part of the skull which it incloses; from the angle forward it is small and blunt, and fits closely into the alveolar depression above. The tongue bones are largely developed, and make a broad, firm floor under the cavity of the mouth.

Most of the many peculiarities of the head are clearly connected with the form of the mouth, and thus with the kind of food, and manner of catching and devouring it. The jaws are weak, and neither pointed nor sharp-edged; and therefore unfit for catching large, active prey, or tearing any tough vegetable or animal matter. The mouth is broad but very close, when its roof and floor are brought near together; it seems on that account best fitted for catching and swallowing minute animals. The mode of articulating of the lower jaw, and the large size of the depression in the mastoids for the digastric muscle, indicate perhaps that the jaws are opened and shut quickly and continuously with a movement somewhat like that of a duck's bill. The legs are strong, and the feet broad and compact, with long, sharp claws.

This family contains a single genus, well known under the name of Chelys. It embraces only a single species, called Matamata in tropical South America, where it is common. Its habits are little known. From the resemblance of this Turtle to the Chelydroidæ and the Trionychidæ, I am inclined, however, to infer that, like these, it lays spherical eggs.

The family first described by Fitzinger under the name of Hydraspides[1] was soon afterwards united, by J. E. Gray,[2] with the Chelyoidæ; but I believe this to be a mistake,[3] if I am permitted to express an opinion after having had so few

[1] Fitzinger, Syst. Rept., 1843, 8vo.

[2] J. E. Gray, Cat. Brit. Mus., 1844, 8vo.

[3] It has already been remarked in a note, p. 335, that the Turtles united as one natural group under the names of Chelididæ, or Elodites Pleurodères, do not constitute a natural family, but embrace a number of families, linked together by the peculiar structure of the neck, and besides by the close connection between the pelvis and the carapace and plastron. Of these families I have only been able to examine the Chelyoidæ proper with sufficient precision to ascertain fully their family characters. I take, however, this opportunity to call the attention of herpetologists to the differences I have thus far noticed among the other groups. I have already stated above, that, as the Chelyoidæ proper recall the Chelydroidæ, the Sternothæroidæ form in the same manner the counterpart of the Cinosternoidæ, while Pelomedusa and Pentonyx remind us of the true Emydoidæ. The Hydraspides, restricted to the genera Platemys, Rhine-

opportunities of examining these Turtles. The united Chelyoidæ and Hydraspides form simply a section of the family of Elodites in the classification of Duméril and

mys, Phrynops, and Hydraspis, agree in having no temporal arch, while the parietals are broad, long, and flat, and the parietal arch is very narrow and far backward. The type of Hydromedusa and Chelodina, which may also constitute a distinct family, differs from the genuine Hydraspides in its parietals, that are gradually narrowing backward to form a ridge with the upper occipital, carrying the parietal arch even further backward than in the Hydraspides; as in these, the temporal arch is also wanting. The Podocnemides present still more striking peculiarities. As in the marine Chelonioidæ, the parietal and temporal arches are united to form a broad roof over the temporal region. This is the only group of Testudinata in which the peculiarities of the skull of Chelonii and Amydæ are intimately combined. On this account, I expect that the Podocnemides will be found to agree much more closely, in those structural peculiarities which constitute family characters, with the earlier representatives of this order in past geological ages, than with any other type. It is deeply to be regretted, therefore, that the beautiful series of fossil Turtles found by Hugi in the jurassic limestone of Solothurn, in Switzerland, have not yet been examined and described with that minuteness which would furnish the means of a direct comparison with the living types; for they exhibit, more distinctly than any other fossil Turtles I have seen, a surprising combination of Chelonioid and Amydoid characters. This is also the case with the genera Eurysternum, *Münst.*, and Idiochelys, *Myr.*, described by Herm. von Meyer, in Münster's Beiträge, 1839.

It ought also to be noticed in this connection, that the oldest fossil species, referred to the family of Chelonioidæ by Owen in his beautiful illustrations of the British Reptiles, (Trans. Palæont. Soc., 1851,) differ in many respects from the marine Turtles, and present, especially in their oval form, which is quite distinct from that of the living Chelonioidæ, features which are characteristic of the living Emydoidæ, or, rather, common to all the Testudinata of the present period, in the younger stages of their development. By its rounded form and small size, the Chelonia of Glaris differs also greatly from the living Chelonioidæ. It certainly constitutes a distinct genus, characterized by the peculiar proportions in the length of the fingers of the front paddles. A knowledge of these combinations of characters, in the earlier representatives of the order, is of great importance with reference to the question of their succession in former geological periods, and that of their relations to the surrounding mediums. Most of the oldest fossil Testudinata have been referred to fresh-water types, and their occurrence in the oolitic and cretaceous rocks, with other fossils evidently belonging to marine types, has led to the supposition (see Pictet, Paléont., vol. i., p. 440) that they may have been floated into the sea from the adjoining fresh waters. I hold that such an assumption is not necessary. There is no closer relation between the secondary Testudinata and the living representatives of this order than between the fossil Ganoids of the jurassic and cretaceous periods and the living Sauroids; and yet it would be entirely gratuitous to assume that the jurassic and cretaceous oceans were fresh-water basins, because the living species of Lepidosteus and Polypterus inhabit the rivers of North America and of Africa. Again: the occurrence of fresh-water Turtles in the jurassic formation, at a period during which no Chelonioids are known to have existed, would lead to the conclusion that there is no relation between the gradation of these animals and the order of their succession in past times; while it appears, on the contrary, that, far from being genuine Emydoids, the earliest Testudinata exhibit simultaneously synthetic and embryonic features, exactly as we have already observed in many other types. (Comp. Part I., Sect. 24, 25, and 26, p. 107–118.) Now that the families of Testudinata are better defined and more fully characterized, a renewed comparison of the fossil and living representatives of this order would add greatly to our knowledge, especially if the investigation was made with direct reference to the questions alluded to above. The lateral movability of the neck of the

Bibron, under the name of Elodites Pleurodères. Wagler was the first to notice the characteristic lateral movability of the neck of these Turtles;[1] but neither he nor any of the earlier herpetologists availed themselves of this remarkable anatomical peculiarity to separate the fresh-water Turtles into minor groups.

SECTION VI.

FAMILY OF CHELYDROIDÆ.

The family distinguished by Swainson[2] under the name of Chelidridæ rests upon an unnatural combination of the true Chelydroidæ and the Chelyoidæ, as characterized in the preceding section. But, while such an association of these Turtles is contrary to the principles of classification discussed in the first part of this work, it seems more in accordance with the practice generally followed in similar cases to adopt the name proposed by Swainson than to frame another for the family characterized in the following pages. This is the more feasible, as Swainson himself considered the genus Chelydra as the type of the family. All the other naturalists who have written upon the Reptiles unite the Chelydroidæ with the Emydoidæ.

The body of the Chelydroidæ is high in front, and low behind; the middle line along the fixed part of the vertebral column descends from its front end backwards;

Pleurodères, in particular, seems to me to have a deep significance. All the other Turtles, even the Chelonii, as far as their neck is flexible, bend it in the perpendicular plane of the longitudinal axis of their body, in the shape of an S, more or less arched. The Pleurodères, on the contrary, turn it sidewise, and conceal it under the projecting edges of the carapace and plastron, in the same manner as the Birds hide their head under the wing. Thus this anatomical character excludes the Pleurodères entirely from the natural progressive series which begins with the Sphargididæ and ends with the Testudinina, and stamps them as a distinct type, bearing among Testudinata a similar relation to the two sub-orders of Chelonii and Amydæ, characterized above, (p. 308,) as the Marsupials bear to the placentalian Mammalia. There is even this remarkable analogy between the representatives of these two classes, that, as among the Marsupials and the higher Mammalia the families correspond, to a great extent, to one another, so also the families of the Pleurodères recall the families of the other Testudinata. The Emydoid form of Owen's Chelone Bensteḍi, from the chalk of England, its small size, and its early appearance in the geological series, render the supposition quite plausible, that it may as well be a Chelonioid Pleurodère as a genuine Chelonioid. At any rate, it has in no way the form of a marine Turtle.

[1] See Wagler's Natürliches System der Amphibien, p. 214 and 218.

[2] SWAINSON, (W.,) Natural History and Classification of Fishes, Amphibians, and Reptiles, London, 1839, vol. 2d, p. 116. The family name ought to be spelled Chelydroidæ, and not Chelidridæ.

the outer edge descends steeply from the front margin to about midway, and rises from thence backward, but less steeply. Thus the upper surface is a shed-roof falling backwards, and curved down on either side, lowest about the middle, less and less toward the ends. The arch from side to side is somewhat flattened on the top for nearly the whole length of the back. The base, or flattened part of the lower surface, upon which the body rests, is very small; it is but little below the lowest part of the outer edge; it extends lengthwise from near the front end of the body under the whole dorsal vertebral column and a part of the sacrum, not reaching the hind end of the body; it is widest about midway, where it includes between a third and a half of the width of the lower surface; from thence it narrows to a point behind, and to a blunt but narrow end in front. Thus the space around it, that is, between it and the outer edge of the body, is very broad, including the greater part of the whole lower surface; it is high and steep in front, lower and more horizontal behind. The carapace projects beyond the attached surface of the body all round, except where it passes over the neck, and where it is joined to the plastron. At the suture with the plastron it is turned somewhat down.

The plastron is fixed, on either side, to the outer edge of the carapace where it descends the lowest, about midway between the front and hind ends, from the arch of the fourth to that of the sixth pair of ribs, sometimes extending a little beyond, and sometimes not quite reaching, these bounds; from thence inward it descends a little, and narrows very fast toward the base, or flattened part of the lower surface, where it lengthens again much faster, and spreads out under the whole of that surface, and as the free edges do not project, they take its form and size. Thus the whole plastron is small. The bridge which passes from its lower flattened part to the carapace is extremely narrow; the openings in the shield for the protrusion of the head and limbs at the ends of the body are large, including much the larger part of the whole lower surface; the front opening is high and exposed, and the hind one low under the body, and protected; these two openings are separated from one another on each side only by a narrow isthmus.

The shield in the adult is completely ossified, and the bony derm is regularly divided into plates, and more intimately connected with the true skeleton than in the Trionychidæ. In the carapace, the eight costal plates, the vertebral row, and the marginal rim, are constant. The vertebral row is continuous from one end of the carapace to the other; it consists of twelve plates in all, eight of which correspond to the costals, and lie between them, being fixed to the vertebræ below; one reaches from the first of these forward between the first pair of costals into the marginal rim, terminating it in front; three more carry the row back to its hind end, the last one entering into the marginal rim, and terminating it behind.

The marginal rim consists of eleven pairs, besides the odd ones at the ends, just mentioned. In the plastron there are nine plates, four pairs and one odd one. The second and third pairs unite with the marginal rim, form the narrow bridge, and then, stretching out lengthwise, form the larger part of the whole plastron. The first pair meet at the front end before the attachment of the shoulder apparatus, under the neck, where they are broadest, and then growing narrow, reach backward and outward and overlap the outside of the second pair. The odd plate is quite small; it is situated just back of the first pair within their angle, and sends a slender slip back some distance between the inner edges of the second pair. The fourth pair meet under the pelvis, terminating in a point just behind it, and reach forward and outward and overlap the third pair; they are broad where they meet, and grow narrow forward.

The scapular arch is high, and nearly perpendicular; it is much higher than broad, so that the shoulders are not nearly as wide apart as in the Trionychidæ, and not so near the outer edge; the coracoid process, the acromion, and the scapula are all long, especially the latter; the coracoid process is broad at its ends. The sacrum is broad; the iliac bones reach far forward, and approach each other as they descend from the sacrum, so that the hip joints are placed under the body far inward of the outer edge of both the end and the sides of the shield; the pubis and ischium reach steeply downward, and the processes of the pubis, which are long and strong, reach downward and forward, and not sidewise. The legs and feet are large and strong, the toes are stout, and all but the outer one of the hind feet terminate in long, curved, sharp, strong claws; they are freely flexible, but not capable of being spread nearly as wide apart as those of the Trionychidæ, and the web is much smaller, the whole foot being more compact than in the latter family.

The dorsal vertebral column is deep from the shield downward, and there is a large space for the longissimus dorsi on either side of it above the ribs for its whole length; the size of this space is connected with the flattening of the shield above. The isolated true bone, situated at the front end of the body, is quite distinct and prominent; it sends long, slender arms on either side under the marginal rim, as far back as to the ends of the second pair of ribs.

The neck is long, flexible, and stout, and has a powerful muscular apparatus. The tail, or, more properly speaking, that part of the vertebral column which extends behind the sacrum,[1] is very long and strong, much longer than the column between it and the neck. This is the case in the American genera, at least.

[1] The great length and strength of that part of the vertebral column which extends beyond the sacrum is not simply to be considered as relating to the size of the tail; the part which this region

The head is large; it is narrow about the nose and eyes, but grows rapidly broad backward to the ear region. The floor of the skull, that is, the roof of the mouth and the base of the brain-box, taken as a whole, is on nearly a horizontal plane; the top of the skull in passing forward over the brain descends as steeply, and in Gypochelys Temminckii much more steeply, than in passing over the front part of the head, so that we have here none of the angle which in the Trionychidæ is caused by the turning down of the front part of the skull. The ear region is broad from the brain-box outward, but short from behind forward. The mastoid is short; its hind surface reaches more upward than backward, and the os quadratum below descends in nearly a line with it; thus the back of the head is high, broad, and square. The crest on the brain-box is high. The pterygoids are narrow, and their edges are deeply concave. The breadth of the ear region, the height of the crest, and the narrowness of the pterygoids, unite to give room for the attachment and passage of very large temporal muscles. The arch from the ear to the eye, made up of the jugal, postfrontal, and temporal bones is broad; the parietals project sidewise, and, for some distance back of the eyes, unite with the postfrontals in making a continuous arch over the head; moreover the openings for the eyes and nose are small. Thus the head is much more protected by bone than in any other family of the sub-order, but much less than in the sea Turtles, for there the bony arch reaches to the hind extremity of the head, whereas here the ear region is exposed from above. The sphenoid is short, and does not extend nearly the whole length of the pterygoids. The jaws are strong; they have sharp alveolar edges, and are pointed at the symphyses.

The free skin is loose, and very movable on the neck and limbs; it does not close around the legs above the knees and elbows, and below incloses them only loosely. The shield is covered with large horny epidermal scales, the arrangement of which presents rather generic than family characters, especially those of the plastron. The free skin, where it is most exposed, especially on the under surfaces of the limbs, on the whole front limbs below the elbows, on the neck just behind the head, and on the tail, thickens at numerous points into a kind of tubercles, and on these tubercles the epidermis is hardened into a kind of scales.

of the body takes in locomotion, in this family, reminds us rather of the character of the whole vertebral column in the other Reptiles, in which it constitutes the principal organ of locomotion. Thus we have here a character which is rather Reptilian than Chelonian; and this coincides remarkably with the comparatively greater length of the tail in all the Testudinata during their earlier stages of development. This resemblance of the Chelydroids and other Reptiles is no doubt hinted at in the vernacular name under which the most common North American species is known all over the southern United States, where it is called Alligator-Couta, from the similarity of its tail to that of an Alligator.

On the legs some of these tubercles are enlarged, and their scales form sharp projecting ridges; along the top of the tail there is a row of very strong and large tubercles of this kind, and there are many other large ones about the tail generally, forming on some parts of it a continuous covering.

The animal lives mostly in the water, but makes considerable passages overland. It does not, like the Trionychidæ, remain burrowed in the soft muddy bottom, but rather lies in wait for prey under shelving banks, or among the reeds and rushes. It moves over the bottom with long strides, touching it with the feet, and also striking the water with the broad surface of the feet and of the legs. Both in the water and on dry land, the limbs move in a much more nearly perpendicular plane than in the Trionychidæ, and the body is raised high from the ground; on dry land, a considerable part of the weight of the body thus raised is borne by the long, strong tail, which reaches down to the ground. When the animal is at rest, the elbow is brought up and back, and a little inward; the forearm is turned down, and the flat of the foot rests on the ground; the knee is carried forward but little upward, the leg below the knee is turned back upon the femur, and the foot again turned forward, resting on the ground; the neck is withdrawn so as to carry the back part of the head under the carapace; the tail is bent to one side. See Pl. 4 and 5. In this position, the head, the limbs, and the tail are ready for action, the hind pairs of limbs well protected by their position under the body, and all withdrawn nearly as far as they can be. When danger approaches, the animal does not try to withdraw its head and limbs further into the shield, but resorts to a more active defence. It faces the attack, raises itself upon the legs and tail, highest behind, opens widely the mouth, and, throwing out the head quickly as far as the long neck will allow, snaps the jaws forcibly upon the assailant, at the same time throwing the body forward so powerfully as often to come down to the ground when it has missed its object. As far as regards the will of the animal, this is almost the exclusive mode of defence, for it is slow to retreat, and cannot withdraw entirely into the shield. It catches its prey in a similar way, by throwing the head forward.

Many of the most important distinguishing characters of this family may clearly be traced to its peculiar habits. For example, the height and exposed condition of the front end, the descent of the shield behind, the position of the limbs and consequent form and small size of the plastron, the breadth of the hind part of the head, the strength of the neck and of the longissimus dorsi, the consequent flattening of the upper surface over the latter, and the size of the tail; indeed, nearly all the prominent characters given above are plainly connected with the most marked peculiarity in the mode of life of the family, namely, the defence by action with the jaws, instead of a quiet retreat into the shield.

There is something fierce and defiant in the attitude of these Turtles, at the moment they raise themselves to dart at their enemies, or to seize upon their prey. They are as ferocious as the wildest beast of prey; but the slowness of their motions, their inability to repeat immediately the attack, their awkwardness in attempting to recover their balance when they have missed their object, their haggard look, and the hideous appearance of their gaping mouth, constitute at such times a picture as ludicrous as it is fearful and revolting. Their strength is truly wonderful. I have seen a large specimen of Gypochelys Temminckii bite off a piece of plank more than an inch thick. They take hold of a stick with such tenacity that they may be carried for a considerable distance suspended to it free above the ground. Their food consists entirely of aquatic animals; fishes and young ducks are their ordinary prey. They lay a considerable number of spherical eggs, from twenty to forty and more, which they deposit not far from the water, in holes which they dig themselves, with their hind legs, upon sloping banks. These eggs are rather small in comparison to the size of the animal, about the size of a small walnut. Their shell is not brittle, nor is it as flexible as that of most of the other Turtles.

SECTION VII.

THE FAMILY OF CINOSTERNOIDÆ.

Under the name of Sternothærina, Th. Bell has described a group of fresh-water Turtles[1] which embraces three distinct types so widely different, that, in the present state of our knowledge of these animals, they cannot be arranged together upon any consideration. One of these types is the African genus Sternothærus, which belongs to the Pleurodères,[2] and for which the family name proposed by Bell must be maintained, as a matter of course. The second type is that of the genus Cistudo, which truly belongs to the family of Emydoidæ, as will be shown in the next section. The third type embraces the genera Cinosternum, *Spix.*, and Staurotypus, *Wagl.*, which are the leading representatives of the family of Cinosternoidæ, as characterized below. In the same year in which Bell characterized the genus Sternothærus, J. E. Gray distinguished also a section in the family of Emydoidæ, under the name of Terraphenina,[3] which corresponds exactly

[1] Zool. Journ., vol. 2, 1825, p. 299.

[2] See, above, p. 338, note.

[3] Ann. of Philosophy, 1825, vol. 10, p. 211. The name ought to be written Terrapenina.

to the Sternothærina of Bell. As the name of that group is derived from the genus Terrapene, *Mer.*, which at that time was restricted by Gray to the common Cistudo of the United States, it applies as little to the family of Cinosternoidæ as that of Bell. Major LeConte, in his late attempt to classify the Testudinata,[1] has also perceived the impropriety of leaving the genera Staurotypus and Cinosternum among the true Emydoidæ, and placed them in his second family with Chelydra. Were not the Trionychidæ also embraced by him in that family, this change would have constituted, in my opinion, one of the most important improvements recently introduced in the classification of the Testudinata, for Cinosternum and Staurotypus are as remote from the true Emydoidæ as Chelydra itself, and more closely allied to Chelydra than to any other family among the Amydæ, though they constitute also a distinct family, the characters of which now follow.

The body is long and narrow. The flattened part of the lower surface upon which it rests is much larger than in the Chelydroidæ, occupying at least one half of the width across the middle, and continuing broad forward, between the shoulders, to its front end, and backward, under the pelvis and hip joints, to its hind end, so that the space between it and the projecting outer edge of the body above is much less in this family. The outer edge of the body is not nearly as high at the front end as in the Chelydroidæ, yet it descends steeply to about midway, but keeps upon nearly the same level around the hind end. The upper surface rises along its middle line, from the front end to the middle of the body and beyond, to near the seventh dorsal vertebra, from whence it falls steeply to the hind end; consequently the body is highest far back of a transverse section through the middle of the body; and as the hind end is as broad, or broader, than the front, the bulk of the body is also thrown backward. These peculiarities will always clearly distinguish the carapace of this family from the shed-roof of the Chelydroidæ, or the more regularly arched cuirass of the Emydoidæ. As the outer edge falls from the front end backward, while the middle line rises, the upper surface, in order to reach the margin, has to descend far down on either side, except about the front end, and, as the body is never wide, it must descend steeply. The outer edge of the carapace is raised, all round, considerably above the lower flattened surface of the body. It meets the plastron, and is sutured to it along the two marginal plates which correspond to the third and fourth ribs, and is there slightly turned inward and downward; but from this suture, either way about the ends of the body, it projects free, a little distance beyond the attached surface, and flares outward.

The free edges of the plastron, that is, the outer edges, where not joined to

[1] Proc. Acad. Nat. Sc. of Philadelphia, 1854.

the carapace, also project beyond the attached surface of the body. As the flattened surface is so broad here, the bridge which connects it with the outer edge of the carapace is much shorter than in the Chelydroidæ, and rises more steeply, but its ends are less concave, and it is broader.

The whole shield is ossified. The arrangement of the bony plates is, in some respects, quite peculiar. The costal plates are constant, eight in number; the marginal plates, too, are constant; there is one odd one at each end, one for each costal, and two from the front odd one to the first of those which are attached to the ends of the ribs, and one from the last of these to the hind odd one, making twenty-four in all. But the vertebral row is deficient; it varies in number from five to seven, the last two or three being wanting, so that the upper ends of the corresponding costals meet one another, and sometimes the front one is equally wanting, so that the first costals meet also. The plastron, in the adult at least, is made up of only eight plates, four pairs; for there is no odd one, as in all the other families of the sub-order. In consequence of the absence of an odd bone in the plastron, the median suture extends without interruption from one end of the plastron to the other, dividing it into equal halves along the middle line. The two pairs of plates, which reach entirely across the body, and are sutured to the carapace, do not make up more than one third of the whole length; they are but little longer in the body of the plastron than in the bridge from thence to the carapace. The front and hind pairs are both broad as well as long; they are generally joined to the other pair by a flexible hinge,[1] except the hind pair in Ozotheca; but in old age these hinges are either partially or completely ossified. The middle transverse suture is always thoroughly ossified, and never flexible.

The fixed part of the vertebral column rises backward with the middle line of the carapace nearly to the seventh vertebra, and thence descends steeply. The tail is never long and strong enough to aid in bearing the weight of the body, as it is in the Chelydroidæ. In the males it is much larger and longer than in the females, and terminates with a horny nail.

The body projects farther beyond the upper part of the scapular arch than in the Emydoidæ, and that arch is carried far back in descending to the plastron, so far that the coracoid reaches across the middle transverse suture. The pelvis,

[1] The movable parts of the plastron are thus different in their composition and in their attachment from those of Cistudo and Emys, inasmuch as in Cinosternoidæ they swing upon an immovable transverse beam, consisting of two pairs of plates which are soldered to the sides of the carapace, while in the Emydoids with movable plastron the hinge divides the whole plastron transversely into halves which swing upon one another, and the sides of the plastron, where they meet the carapace, remain also movable.

too, in descending to the plastron, reaches far forward; it is short across the pubis and ischium, and the processes of the pubis extend sidewise rather than forward; the iliac bones arch outward, but are about the same width apart at the shoulder joints as at the sacrum. The shoulder apparatus and pelvis approaching each other so nearly at the plastron, and filling the intervening space with their muscles, press the organs of digestion and respiration, and the other viscera, up into the carapace. The bones of the shoulder apparatus and of the pelvis, and those of the legs and feet, are all slender. The feet are short and round. The toes are freely movable, and joined by a web, and the whole foot very flexible within itself, and at the joint with the forearm and leg.

The head is long from the orbits of the eye backward, and short from thence forward; it is pointed in front. The upper maxillaries and intermaxillaries retreat backward and inward, so as to make the mouth small, and carry it far inward, under the head. The outer surface of the lower jaw also retreats in the same manner, so that the sides of the front part of the head slant inward from the top to the bottom. This makes the lower jaw short, and enables the temporal muscles to act upon it to advantage. These muscles have a long attachment to it, and are themselves very large, so that the bite of the animal is strong. The alveolar surfaces are broad, and the edges sharp; the lower jaw always terminates in a sharp point. The trough by the side of the brain-box, over which the temporal muscles pass, is very long; but the mastoids project but little backward, beyond it. The arch from the top of the skull, back of the eye, is very short; thus differing essentially from the broad roof of the Chelydroidæ. The temporal arch, from the ear opening forward, over the temporal muscle, is wide. The maxillaries reach back under the jugals to the temporals. The bottom of the skull-box and the palate rise continually forward to the nasal region, and approach so nearly to the top of the skull as to leave only just room enough for the passage of the olfactory nerve. The neck is long, but has not nearly as large a muscular apparatus as in the Chelydroidæ; it is also much more slender.

The shield is everywhere covered on the outside with large horny epidermal scales, which, in different genera, present considerable differences in their arrangements, especially upon the plastron. The free skin is loose, and folded around the body and limbs; its epidermis is thickened into scales in several isolated places on the legs, and under the feet, and there only these scales are continuous and imbricated. The average size of the representatives of this family is smaller than in any other family of Testudinata. The largest, which is about nine inches long, is not nearly as large as the smallest of the Chelydroidæ, or as the largest of either of the other families; and the smallest Ozotheca, which is about four inches long, is not larger than the smallest of the Emydoidæ.

The animal dwells mostly in the water, but comes out from time to time and basks in the sun on the shore, or on any exposed surface, usually in such a position that at the first approach of danger it may drop directly down into the water, or reach it quickly. The slender legs are ill fitted for travelling on dry land, but easily carry the body through the water over its bottom. When surprised away from the water, the animal seeks the nearest hiding-place; if the danger is close at hand, it quickly withdraws the exposed parts into the shield, and, if pressed still farther, it resorts at last to biting, not throwing the head quickly and forcibly out as the Chelydroidæ do, but stretching it out rather slowly towards the assailant, and then snapping the jaws forcibly upon it. The manner of withdrawing the legs is very peculiar. The fore legs are carried round before the body; the elbow, somewhat raised, is carried directly back by the side of the head and neck into the scapular arch, the skin at the same time rolling off towards the feet and shoulders, and leaving its muscles as naked as those of the neck and scapular arch about it; the forearm is turned back, but not quite on to the humerus; the hand is either laid in against the head and neck, or turned back on to the humerus. See Pl. 4 and 5. The hind legs are withdrawn nearly horizontally, the knees like the elbows, though in a less degree, stripped of the skin; the foreleg is turned back upon the femur, and the foot again turned forward upon the foreleg. The tail is turned to one side. The head is drawn back to within the scapular arch, the skin rolling off from the neck, but not folding together before the head, as in the Emydoidæ. When the plastron is hinged, its ends are raised so that the limbs are pressed still farther up into the carapace.

The food is principally animal, but whether exclusively so or not, I do not know. As stated above, the habits of these Turtles are entirely aquatic. Their natural dispositions are a singular mixture of shyness and of fierceness. They remind us of the Insectivora among Mammalia, the rapacious habits of which are also in strange contrast with their small size and feebleness. Their motions are also quick, though awkward, and almost feverish. When they bite, they strike repeated blows, darting the head only, and not the whole body, as the Chelydroidæ do, — the short tail, and especially the slender limbs, affording no adequate means to throw forward the whole bulk of the animal with sufficient force to aid in the assault.

The Cinosternoidæ lay few eggs only, from three to five, which they deposit on the shore near the water's edge, in holes dug with their hind legs. The eggs have the form of a rather elongated ellipse, with very blunt ends. They have a shining glazed surface, much smoother than that of other Turtles. Their shell is very thick and brittle, even more so than in the Trionychidæ.

SECTION VIII.

THE FAMILY OF EMYDOIDÆ.

Since the genus Testudo of Linnæus began to be subdivided into minor groups, and before the family of Emydoidæ was circumscribed within its present limits, the fresh-water Turtles have been combined, by different authors, in various ways with one another and with the land Turtles.[1] J. E. Gray tells us, that Th. Bell was the first to consider them as a separate family,[2] distinct from the Trionychidæ, which, five years later, are still united with them by Wagler.[3] At that time, however, Gray associated the Chelyoidæ with the Emydoidæ; and though he afterwards separated these two families, the Emydoidæ still include the Chelydroidæ and the Cinosternoidæ in his latest publications.[4] Fitzinger,[5] in 1826, and Wiegmann,[6] in 1832, adopted also the family of Emydoidæ as distinct from the Trionychidæ or Chilotæ, while, in 1836, Canino[7] considers it as a sub-family of the Testudinidæ, as he calls the Amydæ, exclusive of the Trionychidæ. In 1835, Duméril and Bibron[8] unite the Emydoidæ and Chelyoidæ as one family, under the name of Elodites; distinguishing, however, the Emydoidæ as Elodites Cryptodères, to which they still refer Chelydra and Cinosternum, from the Chelyoidæ, which they call Elodites Pleurodères.

This is by far the most numerous family in the order, as it includes over sixty well known species; it presents also the broadest range of differences in habits, size, and structure.

The body rests upon a very broad and long flattened surface. It is high, and arched upward both lengthwise and crosswise, highest and broadest about the middle. The median longitudinal arch is not regular, but descends more steeply as it approaches the ends; the sides, too, curve more sharply around the ends than about the middle; the outlines, however, have no well defined angles so combining as to divide the body into distinct regions, but run gradually into one another, and the whole carapace is like an overturned elongated bowl. The plas-

[1] Comp. Chapt. 1, Sect. 2, p. 241.

[2] See J. E. Gray's genera of Reptiles in Ann. of Philos. 1825, vol. 10, p. 210, where that family name is spelled Emydidæ. Bell also writes it Emydidæ in the Zool. Journ. 1825, vol. 2, p. 302.

[3] Natürl. System der Amphibien, 1830.

[4] Cat. Brit. Mus. 1844.

[5] Neue Classif. der Reptilien, 1826; under the name of Emydoidea.

[6] Handb. d. Zool. 1832.

[7] Chelon. Tab. Anal. 1836.

[8] Erpét. génér. vol. 2d, 1835.

tron is very large, underlying the whole lower surface. The carapace is raised considerably above the flattened part of the lower surface, and its outer edge, where it meets the plastron, is turned abruptly downward and somewhat inward, and the adjoining edge of the plastron is turned abruptly upward and somewhat outward. The edges meet thus, and are joined from the first to the fifth rib, so that a large part of the body, including the bulk of the organs of digestion, circulation, and respiration, and situated under the second, third, and fourth, and parts of the first and fifth costal plates, is completely encircled by the shield. The body itself is broadest here, and narrows rapidly to the ends. The free edges of the carapace, that is, the edges which do not meet the plastron, project beyond the body, and flare outward; the free edges of the plastron also project beyond the body, so that the exposed parts, at the openings about the ends, are protected by projections of the shield, above and below. Where the body is entirely encircled, the shield fits closely to it; still, on account of the greater expansion of this region, the flattened surface of the plastron under it, and the arch of the carapace over it, are nearly or quite as broad as they are at the ends, where the edges project. The fixed part of the vertebral column is arched for its whole length, its highest point being nearly over the middle of the body: the arch, however, like that of the carapace over it, is irregular, descending more steeply near the hind end, but the point where the change takes place is hardly, if at all, perceptible; indeed the change is but slight, and the whole may be considered as one arc, whose cord makes, with the lower surface of the body, an angle opening forward. The iliac bones are nearly parallel, making the pelvis about as wide across the hip joints as across the sacrum; they reach but little forward in descending from the sacrum; the scapular arch retreats but little in descending, and the coracoid does not reach the middle transverse suture of the plastron; the shoulders are wide apart. Thus the pelvis and shoulder apparatus do not closely approach one another, as in the Cinosternoidæ and Cylidroidæ; but the viscera within come down on to the plastron between them, and the limbs are carried out nearer the ends and sides of the body. The legs are stronger than in the Cinosternoidæ. The toes vary widely with the habits of the animal; in the most aquatic species they are long, joined by a broad web, and capable of being widely spread; in those that live on land, they are shorter and less flexible, and the web disappears; but in none are the feet stiff enough to raise the weight of the body upon the ends or last joints of the toes, as is the case with the fore feet of the Testudinina.

The sides of the head are pretty regularly curved from end to end, and widest apart between the ear and eye openings. The mastoids reach far backward and upward, and are long, rounded, and pointed; the front wall of the ear cavity reaches forward as well as outward from the brain-box. The brain-box is connected with the nasal region by a long, narrow sulcus, for the passage of the olfactory nerve. The palatines rise continually from the suture with the pterygoids to the prefrontals, but at their front ends they are considerably lower down from the top of the skull than in the Cinosternoidæ. The prefrontals meet from the foramen olfactorium down to the vomer; they retreat below the foramen. The upper maxillaries and the intermaxillaries do not, as in the Cinosternoidæ, retreat in such a manner as to carry the mouth far inward under the head, but are more nearly perpendicular, thus leaving the mouth larger; the jugals come down between the maxillaries and the temporals, except that sometimes a very narrow process from the former projects back under the jugals, and meets another from the temporals. The jaws vary widely, but never terminate in the long, strong, sharp points which exist in the Cinosternoidæ.

The shield is not completely ossified till late in life, and the bony plates are very constant and regular in their arrangement. The carapace consists of the usual eight costal plates on each side, of eight vertebral plates attached to the fixed vertebræ, and of two more plates not so attached, which continue this row backward to the marginal rim; in the rim there are eleven pairs of plates and one odd one at each end, making in all, twenty-four marginal plates. The number of plates in the vertebral row varies a little, but the row itself is always continuous from the odd marginal plate at the front end to the one at the hind end. The plastron consists of nine plates, four pairs and one odd one. The first pair lies across the front end, before the shoulder apparatus, and under the extended neck; it is the shortest and smallest. The second and third pairs, as in the other families, reach clear across the body, and unite with the carapace on either side; these two pairs are much longer in the body of the plastron than in the bridge which extends from thence to the carapace; they make more than two thirds of the whole plastron. The bridge sends off from each end a long process, which is fixed into the carapace above; when the plastron is hinged, these processes are very small, or entirely wanting. The hinge, when it exists, is always between the two middle pairs, and never, as in the Cinosternoidæ, between them and the adjoining pairs.[1] When there is a hinge, the edges of the carapace and plastron are united by a narrow, flexible, unossified dermal ligament. The odd plate is just back of the suture which unites the first pair to one another, and between the fore part of the edges of the next pair; it sends back a slender, pointed process for some distance over the suture of the second pair. The fourth pair lies under the pelvic region; it is larger than the first pair, but smaller than the second or third.

Large epidermal scales cover the outside of the whole shield, the form and

[1] Compare the note of p. 348.

arrangement of which vary somewhat in different genera. The skin of the head, neck, limbs, and tail, is all more or less covered with scales, and where the surface is exposed, when the limbs are retracted, or when the animal is walking, the scales are imbricated, and form a continuous covering.

The habitat varies widely in this family. Nearly all live more or less in the water, in marshes and pools, or along the edges of ponds and still streams; but one genus, at least, never seeks the water, and with those that do, the proportion of life passed in that element varies exceedingly; indeed, the family presents a gradual series, from those which are almost exclusively aquatic to those which live always on land. In swimming, the feet and legs move in a plane nearly parallel to that in which the body is moving, that is, horizontal, if the animal is moving horizontally. In walking, also, the humerus and femur move nearly horizontally, which is made necessary by the great width of the plastron under them; but at the elbows and knees, which move around or beyond the edge of the plastron, the legs are turned down to an angle, greater or less, according as the body is raised to a greater or less height from the ground; but the knee, even when brought farthest forward, is never opened to a right angle, as it is in the Testudinina, and the body is not raised up upon the ends of the toes of the fore feet, but the whole foot of both pairs is brought to the ground. Thus the body is not carried so high as in the Testudinina, and the gait is much less firm and steady. When molested, these Turtles resort to the nearest hiding-place; the aquatic species, if near the water, seek that as the first shelter; if hindered in this, they withdraw the head, limbs, and tail into the shield, and, if pressed still further, they stretch out the head and bite. When they retreat within the shield, the head is carried far back between the shoulders, and the neck drawn in naked among the viscera; the legs are folded between the inner parts of the projecting free edges of the shield, and the tail is turned to one side.

The knees and elbows do not, as in the Cinosternoidæ, slip in naked among the viscera, but the skin keeps its position close around them. The humerus is carried round before, and almost directly across, the front end of the body, but a little raised at the elbow; the forearm is turned back upon the humerus, and the foot upon the shoulder, the toes reaching to the shield where the edges of the carapace and plastron meet. See Pl. 1, 2, 3, 4, and 5. The elbows do not come together, but leave room between them for the passage of the head. The head is often placed between the elbows, but sometimes drawn further back; in the latter case, the skin folds together before it. The femur is carried round by the side of the pelvic region, so as to reach almost directly forward, but a little upward; the foreleg is turned back upon the femur, and the foot so turned forward that the inner edge rests upon the foreleg. When the limbs are in this position, the toes of the hind feet are at or very near the shield where the edges of the carapace and plastron meet, so that the entire surface on each side between the fore and hind leg is protected by the bridge which connects the lower flattened surface of the plastron with the outer edge of the carapace. Thus the retracted limbs and the tail are placed nearly horizontally between the projecting free edges of the carapace and plastron; but when the plastron is hinged, its ends are raised, and they are pushed further upward and inward.

The size varies exceedingly in this family; it is larger than in the Cinosternoidæ, and smaller than in the Testudinina. The smallest known species, Emys Mühlenbergii, is about four inches long; the largest, Ptychemys rugosa and concinna, are about fifteen inches long. The largest species are among the most aquatic.

None of the species catch active prey, or are in any way ferocious; they are indeed entirely harmless, and only when hard pressed defend themselves by biting; they do not, however, snap repeatedly with the head against their assailants, as the Cinosternoidæ do. Their food is both vegetable and animal; the latter they tear with the jaws, holding it down, when necessary, with the fore feet. In captivity, they are very fond of worms, and green leaves, and berries; the more terrestrial species feed upon grass.

The Emydoidæ, like all other Turtles, lay their eggs upon dry land, in holes which they dig themselves with their hind legs. The number of eggs they deposit at one time varies more, with different species, than in any other family. The more terrestrial species lay the fewest eggs, from two to three, to five or seven; while the aquatic species lay many more, from ten to fifteen, to twenty, thirty, and even more. The form of the eggs is that of a more or less elongated ellipse; the shell is never brittle, but rather flexible, and less calcareous than in most other families.

The minor differences of form, observed among the Emydoidæ, suggest the following subdivisions, which appear to bear the character of sub-families; but, until I have examined a greater number of the species found in South America and in the Old World, I do not venture to insist upon the accuracy of their limits.

1. NECTEMYDOIDÆ. The body is rather flat. The bridge connecting the plastron and carapace is wide, but flat. The hind legs are stouter than the fore legs, and provided with a broad web, extending beyond the articulation of the nail joint. The representatives of this group are the largest and the most aquatic of the whole family.

2. DEIROCHELYOIDÆ. The body is higher and more elongated; the bridge connecting the plastron and carapace is not only wide, but at the same time high. The plastron itself is narrower than in the preceding tribe. The neck is remarkably long and snake-like, and recalls that of the Chelodinæ among the Pleurodères. The feet are webbed.

3. EVEMYDOIDÆ. Differ chiefly from the preceding by the great width and flatness of the plastron, the narrowness of the bridge which unites the plastron and carapace, and the movability of the plastron, at its junction with the carapace, and upon itself, owing to a transverse articulation across its middle. The feet are webbed.

4. CLEMMYDOIDÆ. Their chief peculiarity consists in their more arched though elongated form, and the more compact structure of their feet, the front and hind pairs of which are more nearly equal, and the toes united by a smaller web. They are less aquatic, and generally smaller than the preceding.

5. CISTUDININA. The body is remarkably short and high, slightly oblong, and almost round. The plastron, which is movable upon itself and upon the carapace, as in the Evemydoidæ, is also connected with the carapace by a narrow bridge; but the feet are very different, the toes, as in the Testudinina, being nearly free of web. Their habits are completely terrestrial.

SECTION IX.

THE FAMILY OF TESTUDININA.

The land Turtles are now generally considered as a primary division among the Testudinata. J. E. Gray was the first to separate them, under the name of Testudinidæ, as a distinct family,[1] which was soon afterwards adopted by Fitzinger[2] and Th. Bell.[3] In 1828, Ritgen changed the name of the family to Chersochelones.[4] In 1830, Wagler[5] proposed the name of Tylopodes for this same family, which he considers, however, only as a tribe of the one family Testudines, to which he refers all the Testudinata. In 1832, Wiegmann[6] considers them again as a family, which he calls Chersinæ, while Canino,[7] considering them only

[1] Ann. of Phil. 1825, vol. 10. In all his later writings, Gray retains the name of Testudinidæ; but as Testudo is a Latin noun, it does not admit of a patronymic ending. The family name of the land Turtles should, therefore, be written Testudinina.

[2] Fitzinger, Neue Classification, etc., 1826, writes the family name Testudinoidæ; but in 1836, Syst. Anord. d. Schildkr., he adopts Wagler's name, Tylopodes, changing it to Tylopoda.

[3] Bell (Th.), in Zool. Journ. 1828, vol. 3, p. 419 and 513. He also writes the name Testudinidæ.

[4] Nov. Act. Acad. Nat. Cur. 1828, vol. 14.

[5] Wagler, Natürl. System d. Amphibien, 1830.

[6] Handb. d. Zool. 1832.

[7] Saggio An. Vert. 1832; compare also Chelon. Tab. Anal. 1836. The family to which Canino refers the Testudinina is called by him Testudinidæ, and is not to be confounded with the Testudinidæ, *Gray*, as it embraces, besides the land Turtles, all the other Amydæ, to the exclusion of the Trionychidæ only, which he separates as another family coequal with the Testudinidæ.

as a sub-family, calls them Testudinina. In 1835, Duméril and Bibron[1] admit this group again as a family, but change the name to Chersites. As this family stands at the head of the series, it needs only to be compared with the Emydoidæ, which are next below.

As in the Emydoidæ, the body rests upon a broad, flat surface, but here it continues broad and full much higher up. There is a general equilibrium throughout the body; and corresponding parts, between a middle transverse section and the two ends, pretty evenly balance one another. The whole form is distinguished by the division of its outlines into three well defined regions: a middle region, including the organs of digestion, respiration, and circulation, and extending from the first and second pairs of ribs, or, what is the same, from the scapular arch nearly to the seventh pair, and two other regions situated at the ends, including and protecting the extremities and some adjoining organs. The middle region is very high, broad, and long, and forms much the larger part of the body; its sides arch outward from end to end, but the cords of their arcs are nearly parallel; the top is straight, or arched upward; when straight, it is nearly parallel to the lower surface, and when arched, its cord is so. Thus the whole region is quite symmetrical, and its ends are nearly equal, and very large. The anterior and posterior regions are comparatively short and small, and the curves which close the ends of the body necessarily drop abruptly down, and turn abruptly about them, to meet the outlines of the middle region at sharp and well defined angles.

In most genera, the top and sides of the middle region are only slightly arched from end to end; but in Psammobates, and in Cylindraspis, they are so much raised as to obscure, at first sight, the distinction between the bulk of the body and the ends. Again, the symmetry of the middle region is somewhat disturbed by variations in the thickness of the shield, and by a somewhat greater elevation of the hind end; but neither of these modifications rises to importance in reference to the essential characters of the form; and on examination, the upper surface, divided and specialized as it is, is readily distinguished from the simply arched, bowl-like upper surface of the Emydoidæ. The regions at the ends very evenly balance one another in bulk, but differ considerably in form; the front one is shorter and broader at the front end, the other more elongated and narrowed toward the hind end; the upper surface descends also much lower behind than in front. As in the Emydoidæ, the openings about the ends, for the protrusion of the extremities, are narrow and small. The carapace is raised considerably above the plastron, a part of its edges turned abruptly downward and inward, and joined to the corresponding edges of the plastron, which are turned abruptly upward and outward, and

[1] Erpét. génér. vol. 2d, 1835.

the free edges above and below project beyond the attached surface of the body. The middle region is the part entirely encircled by the shield. As this region is here so predominant, the plastron is longer and broader under it, and its suture with the carapace longer, and the openings about the ends shorter, than in the Emydoidæ. The other parts of the plastron, that is, the parts which underlie the regions at the ends, are comparatively short and small, narrowing rapidly towards the ends of the body; indeed, they are so reduced as to appear like mere projections; they are both turned out of the general level of the lower surface, the front one turned up and the hind one turned down. The hind one does not underlie the whole of its region, but the body projects beyond it all around the sides and hind end, so that the opening is outside as well as above it. There is a broad space between its outer end and the carapace behind; and, when it is longest, this end is deeply notched. The projecting free edges of the carapace flare outward over these openings. Over the one about the hind end of the body, it flares outward considerably at the sides, but less and less backward, until, just behind the tail, it continues the steep descent of the carapace above, directly down, and reaches nearly or quite as low, and often lower, than the general level of the plastron.

The shield is entirely ossified, and the general arrangement of all the bony plates is similar to that which we find in the Emydoidæ; but the marginal plates are longer, and the two pairs in the plastron which are sutured to the carapace larger, than in that family. To meet the neck, the first one or two fixed vertebræ are turned down more steeply than the carapace above; the first one is in the front margin of the body. Over the middle region, the column follows the general direction of the carapace above, and with it turns abruptly down, shortly before reaching the sacrum, and continues in its steep descent through the latter, and to the end of the tail. As the sacrum is so high up here, the vertebral column below is necessarily very long, before it reaches the surface of the body; it protrudes but little, and the skin does not close around it till very near the end, so that there is only a short, stubbed tail visible. The vertebræ of this part of the column are flattened on the upper and lower surfaces.

The scapular arch is nearly perpendicular, and very high; the acromion and coracoid process are both short, and the shoulders not wide apart; the humerus is broad at the elbow joint, and the tibia and fibula make the forearm broad; the bones of the wrist, hand, and fingers, are all short and compact, and move but little upon one another, or upon the end of the forearm. The fingers are all close together, down to the last joints; these joints protrude free, and are covered with flat, sharp nails. When the muscles and skin are attached, the foot is kept nearly on a plane with the forearm above, and the whole limb below the elbow is either one continuous broad blade, or a club-shaped stump, terminating in flat, spade-like nails. The pelvis is long from the sacrum downward, and short from behind forward, over the pubis and ischium; it is wider across the hip joints than across the sacrum. It will be noticed, that the dimensions of the pelvis and shoulder apparatus agree with the proportions of their regions of the body, which are both high and short. The bones of the feet and ankles are short and close together, the last joint of the four inner toes only protruding free; these joints are covered with sharp nails, narrower and more pointed than those of the fore feet. There is little movement between the bones of the feet and ankles upon one another, or upon the end of the foreleg; the foot is turned forward at the ankle, and the nails turned down; and, when the muscles and skin are attached, the whole limb below the knee is club-shaped, largest at the bottom, resting on a flat, round base, and having four nails protruding forward and downward from the front part of its lower edge.

The end and sides of the front part of the head are high. The nasal region is broad, and the eyes wide apart. The nasal cavity reaches back, at the top, with its whole width, to the brain cavity, which is also wide here, and the two are separated from one another by a thin, narrow strip of bone, which is perforated by the foramen olfactorium; below this narrow strip the prefrontals do not meet, and there is a large round opening between them, above the vomer. These two cavities fill the upper part of the wide space between the eyes, but below they recede from one another, and the space between them is filled by the palate, which is raised high up at its back end, and continues so to the prefrontals, arching somewhat on the way. The alveolar margin is turned directly downward, and terminates in a sharp edge; the alveolar surface within is occupied by two other ridges, and the intervening furrows; one of the ridges on the inner edge, and one between it and the outer. The lower jaw is high, its alveolar surface narrow, with sharp edges, and both turned up so as to leave a trough between, which, when the jaws are closed, fits on to the middle ridge of the upper jaw. The front wall of the ear cavity does not reach so far forward, at its outer edge, as in the Emydoidæ. The mastoids are short and blunt, and reach no farther back than the occipital condyle, so that the hind part of the head is broad and flattened.

The shield is entirely covered, on the outside, with epidermal scales, and the skin is everywhere more or less protected with them; and on the most exposed parts they are thick and stiff, and form a continuous hard covering, much more impenetrable than in the Emydoidæ. The parts thus protected are the top and sides of the head, the front surface and the edges of the front legs, from the elbow down to the finger nails, and up a little way toward the shoulders, the bottom of the hind feet, and over the heel, and a little way above the back surface of the hips, and the space intervening between them, and over the upper surface of the tail.

The size in this family is greater than in any other of the sub-order. The Gallapago Turtle, Cylindrapis indica, may be rated at about three feet, the African Coui, Psammobates radiatus, at eighteen inches, the South American Chelonoides tabulata at fifteen, our Gopher, Xerobates carolinus, at twelve, and the common European land Turtle, Testudo græca, at eight inches in length. Thus they are all comparatively large,— except the European species, which is the smallest of the whole family,— and, on the whole, by no means as small as some of the Emydoidæ; but the great height and fulness of the body make the relative size still much larger than the comparison of their length alone would indicate.

This family live entirely on dry land; and when placed in the water, they try to walk as if on land, having no true swimming motion. In walking, they carry the body high up from the ground; the legs are not spread so far apart, and move in a plane more nearly perpendicular, than in the Emydoidæ; moreover, as the hands are fixed in the plane of the forearm, the body is raised up on the ends of the fingers, or at least upon the last joints; the hind legs rest indeed upon the whole lower surface of the foot but the knee joint, when the foot is first brought to the ground, is open to about a right angle, and the foreleg, which is always long, is nearly perpendicular, so that this end of the body is raised to about the same height as the other. They walk with a firmer and more steady gait, and travel for a distance with greater rapidity, or rather less slowly, than any other Turtles. The front leg is carried forward, and the sharp, spade-like nails being fixed to the ground, the body is pulled toward it, the elbow joint closing, and the forearm and humerus approaching one another. The deltoid muscles, which do the most in pulling the body forward, are here very largely developed. The hind leg is carried round to the side of the pelvis, so that the humerus, then nearly horizontal, reaches almost directly forward; the knee is bent to about a right angle, and the whole lower surface of the foot, with the nails, rests upon the ground; then as the body is pushed forward, the angle of the knee-joint opens, and the leg straightens out. The simultaneous opening of the knee and closing of the elbow keep the body, while moving, steady on one plane, and there is here a regularity in the walking motion far beyond that of any other family of Testudinata.

The animal has nothing of the ferocious dispositions of most other families; it always retreats from attack, and will not bite, even when pushed to extremity; it first seeks some hiding-place, but if it is hindered in this, and the danger is close at hand, it resorts to its shield, and trusts solely to it for protection. The head is withdrawn far back, but the skin does not roll off from the neck so far as to fold together before it, as in the Emydoidæ. The humerus is carried round before the body, the knees brought together before the head, and the forearm and hand turned back upon the humerus. See Pl. 3. The knees meet before the humerus reaches directly across the body, and they are somewhat raised above the shoulders, which is made necessary by the rise of the plastron forward, so that the humerus reaches somewhat outward and upward, and not exactly across the body. The blade formed of the forearm and hand is nearly as broad as the opening about this end of the body, and when the knees are brought together the opening is almost entirely closed, and the surface of the forearm and hand exposed before it. The femur is carried to the side of the pelvis, reaching upward as well as forward, so that the knee is raised high up within the carapace; the foreleg is turned down and back upon the femur, and the foot and hip thus brought together occupy the whole open space by the side of the plastron, so that the bottom of the foot and the hind surface of the hip only are exposed. The short, stubbed tail is bent directly forward (when longest a little curved) between the hips, so as to cover most of the surface behind the pelvis. All the parts exposed when the limbs are thus withdrawn are covered with thick, hard scales.

The food of this family is exclusively vegetable. They seem to prefer the succulent stems of plants and fleshy fruits to leaves or grass. I have often seen our Gopher gnawing the stumps of cabbage and the apples falling from the trees, in my garden, as the squirrels do, holding them between their feet. This vegetable diet seems to affect essentially the structure of the digestive apparatus, for in our Gopher (the only genus examined) the large intestine is longer than all the rest of the alimentary canal, including the stomach and œsophagus, whereas in no one of the many genera which have been examined of the families of Emydoidæ, Cinosternoidæ, and Chelydroidæ, does the proportion reach as high as one to five. The lungs are very much larger in the Testudinina than in any other family of the sub-order, which is undoubtedly due to the exclusively terrestrial habits of the animal.

These two peculiarities of structure, the great length of the large intestine, and the large size of the lungs, directly traceable to the habits of life, go far towards giving the middle region of the body its peculiar size and form. A connection will readily be seen also between the proportions of the terminal regions, which are high and short, and the manner of walking and of withdrawing the limbs, inasmuch as the legs move in a plane so nearly perpendicular, and the knee and elbow joints are raised when retracted so high up within the carapace. Again, the equilibrium throughout the body is clearly connected with the steady, straightforward motion in walking. Thus this family exhibits, more closely than any other, the direct relation which exists between the form and structure.

SECTION X.

ON THE BRAIN OF THE DIFFERENT FAMILIES OF NORTH AMERICAN TURTLES.

In the description of the families of Testudinata, given in the preceding sections, only such structural features have been considered as bear directly upon the form of the animal. It would, however, be very interesting to ascertain further, how far the form of all the different organs is also characteristic of families in general, especially since it has already been shown that the development of some of the organs,[1] at least, has an immediate influence upon the form of the body; but I have thus far refrained from making such an investigation, as it would require more extensive comparisons than could properly be introduced in this part of my work. Yet, as I knew, from dissections made upon a large scale, many years ago, that the form of the brain is characteristic of the different families of Fishes, I have thought it desirable to extend these comparisons to the Testudinata, in order not to leave the subject entirely out of sight. The result of this comparison coincides fully with that obtained in the class of Fishes. It stands proved, that while the form of the brain has no immediate bearing upon the form of the skull[2] and of the head in general, it is yet typical in every family.

All Turtles agree among themselves very remarkably in the structure of the brain. From the large hemispheres, the transverse diameter of which is about equal to one half of its whole length, the brain grows narrow forward and backward. The relations of the different parts of the brain are remarkably constant in the whole order of Testudinata; so much so, that, of all the organs, the brain seems the least likely to undergo deeper modifications in one and the same group, and therefore to be not only one of the most important organs of the Vertebrata, but also one of the most characteristic, in a zoölogical point of view. However much the Turtles may assume, in their external organization, characters of the higher Vertebrata, (of Birds and Mammalia, for instance,[3]) still, in relation to the brain, they preserve fully the Reptilian character. Their brain remains slender and long. This fact is very striking when we compare the head of a Turtle with that of a Mammal or that of a Bird.[4] The skull of a Turtle

[1] See Chap. 1, Sect. 11, p. 282.

[2] This result is in glaring contradiction with the doctrines of Phrenology.

[3] Comp. Chap. 1, Sect. 18, p. 308–312.

[4] In these, the brain-box is much more distinct from the bones of the face and jaws than in Turtles.

is compact, like that of a Mammal, and generally very broad; but the brain-box and the brain are slender and small, while in all Mammalia and in all Birds, in which latter the skull is often very slender, the brain is broad, short, and high. The large development of the muscles, and especially of the bony framework of the head, and not that of the brain, accounts for the broad form of the skull of the Testudinata, the locomotive apparatus of the powerful jaws being chiefly placed on the sides of the skull. As we have already given a brief sketch of the brain of Turtles in general, when treating on their nervous system,[1] we have now only to compare the brains of different families with each other.

In spite of the constancy in the proportions of the brain, in the whole order, some differences may be noticed when comparing singly the parts of the brain of different families with one another. In the first place, it may be remarked, that the two sub-orders described above as Chelonii and Amydæ seem as well justified by the peculiarities of their brain as by the other characters they exhibit. In the sub-order of Chelonii proper, the large hemispheres are more cylindrical, nearly as high as broad, and, without broadening and forming an outgrowing angle behind, they taper into the posterior part of the brain, the corpora quadrigemina; while, on the contrary, in all the Amydæ, the hemispheres are much more depressed, generally marked with some folds, and always widen backwards, so as to form there an abrupt angle with the rest of the brain. This is particularly the case in Trionychidæ, much less so in Chelydroidæ, more again in Cinosternoidæ, and still more in Emydoidæ and in the land Turtles. In this respect the latter, the Testudinina, stand next to the Trionychidæ, which, as far as this point is concerned, seem to rank first. The large hemispheres are nearly smooth in Trionyx; in the Emydoids, and still more in Testudo, we see fine folds run along them. The corpora quadrigemina are largest in proportion to the hemispheres, and more longitudinal in Chelonii proper, smaller and more rounded in Amydæ, and often nearly entirely received into the posterior excavation of the hemispheres, as in Trionyx. The cerebellum is remarkably high in sea Turtles; it is flatter and thinner, more like a bridge, over the fourth ventricle, in the Amydæ. It is remarkably broad in Trionyx and Emys, narrower in Cinosternoidæ and in Chelydroidæ. In sea Turtles, the fourth ventricle is narrow; broader in the Amydæ, and very wide in land Turtles. In Trionychidæ, Chelydroidæ, Cinosternoidæ, and Emydoidæ, the whole ventricle has a constant typical shape; that is to say, it is much more slender when compared with that of the land Turtles, and broader in front; then follows a contraction, when it widens again, and runs out into a long.

[1] Comp. Chap. 1, Sect. 8, p. 274.

pointed angle. This contraction is greatest in the Cinosternoidæ, less in Chelydroidæ, Trionychidæ, and Emydoidæ. The hind part of the ventricle, which follows the contraction, is very long in Trionychidæ, Cinosternoidæ, and Chelydroidæ, but less so in Emydoidæ. In land Turtles, the ventricle is very wide; the contraction in the middle is nearly wanting, and the whole is very short. In relation to this ventricle, Cistudo shows again beautifully its standing as the highest among the Emydoidæ, and next to Testudo. Its ventricle is broader and shorter than in any other of the Emydoidæ. The lobi olfactorii are generally very much developed in Turtles, and the nervi olfactorii rather strong. They are, however, different in different families: longest and most slender in sea Turtles, very short and strong in land Turtles, more slender again in Chelydroidæ, Cinosternoidæ, Trionychidæ, and Emydoidæ. Accordingly the cavity of the nose also is very large in the herbivorous land Turtles, smaller in Chelonii proper, as well as in Emydoidæ, Cinosternoidæ, Chelydroidæ, and smallest in Trionychidæ,[1] in which the sense of smelling, in spite of that long, protracted proboscis, seems very little developed, as is generally the case in aquatic animals. In Testudo, and in Chelonii proper, the hemispheres and the nervi olfactorii lie in a thick cartilaginous trough, which extends as far as the nasal cavity. This trough is very broad and rather short in Testudo; narrow and long, on the contrary, in Chelonii proper, according to the proportions of the lobi and of the nervi olfactorii. In all the other Turtles that trough is much thinner; in some, as in Cinosternoidæ, it is little more than a stiff membrane. This trough is in fact nothing but a part of the cartilaginous skull-box, which remains unossified throughout life. We find also some marked differences in relation to the nervi optici. In Trionychidæ, the two nerves pierce the trough, mentioned above, very near together, so as nearly to touch one another; on the contrary, in Testudo the nerves separate widely before they run through the skull-box, and the distance between the two holes through which they pass is about as great as the breadth of the lobi olfactorii above them. In Cinosternoidæ and Emydoidæ (including Cistudo) we find the holes for these nerves as near together as in Trionyx; in sea Turtles only they are more distant,

[1] The whole of that long, protracted nose so characteristic of the Trionychidæ, is not so much an organ of smelling (as the proboscis of some Mammalia, the South American Nasua, for instance) as an organ of respiration, and probably also of touch. These Turtles, while lying in shallow water, stretch out their nose from time to time to the surface of the water for the sake of breathing; but under the water, when moving in the mud, this long proboscis has very likely a similar function to the long, protracted proboscis of the Shrews and Moles, when burrowing under ground, and groping for worms and larvæ of Insects. Trionyx may find its food in the same way, which consists in mud shells (as Paludinas and Anodontas) and larvæ of Neuroptera, by feeling about with its proboscis. Its fleshy lips, the use of which is not yet known, may help in the search, as they are movable.

though not nearly so much so as in Testudo. After the nerves have passed the skull-box, they run, in Trionyx, first sideways in a right angle, and after a short while, in a second knee, forward to the eyes. In Testudo they run also sideways in nearly a right angle, but pass into the eyes without forming a second knee; in Emydoidæ they bend in a wide angle, or rather in a curve, forward and sideways; while in Chelydra and Cinosternum they run very much as in Trionyx; finally, in Chelonii proper they run forward and sideways, as in Emydoidæ.

Though there can be no doubt that the brain is the organ to which all the passive and the active manifestations of the psychical life of vertebrate animals must be referred, nothing is yet known of the ways in which the peculiar kinds of psychical manifestations of an animal are connected with the peculiarities of structure of its brain. This is a field hardly touched yet by naturalists, though a knowledge of these relations alone can give its deeper value to the morphology of the brain. Comparative anatomists must confess, that thus far the innumerable modifications in the form of the brain of Vertebrata have in no way been brought into causal relation with the peculiar psychical faculties of the animals in which they are observed. Nay, animals which have entirely different habits have sometimes identical brains, for instance, Salmo and Coregonus; while others, which hardly differ in their mode of life, present great differences in this respect, for instance, Acipenser, and the large species of the Catostomus tribe.

SECTION XI.

DIFFERENCES IN THE MODE OF LIFE OF TESTUDINATA.

A knowledge of the mode of life of animals is generally considered as furnishing, at the outset, a test of their internal organization, and the means of ascertaining the degree of their affinity. Although this is true in a certain sense, the limits within which there exists such a correlation between the habits of animals and their structure are not at all defined. Among Mammalia, it would seem as if the mode of life coincided with the limits of the orders, if we take, as genuine orders, the leading divisions adopted in that class; though we find already here frugivorous and insectivorous Chiroptera, etc. Among Birds, the diet is still less restricted to the orders; we find herbivorous and piscivorous species in the same family, for instance, among the Ducks. Among Turtles, we have seen that the limits, within which the habits, the mode of life, and the diet, are the same, coincide with the natural limits of families. The Chelonioidæ are all herbivorous, inoffensive, and shy. The Trionychidæ, on the contrary, which live upon fresh-water shells and the larvæ of aquatic insects, are quick in their motions, and bite about them like Snakes; while the Chelydroidæ, which live upon a large and active prey, are as ferocious as the wildest carnivorous beasts. The Cinosternoidæ, though also carnivorous, are rather active than fierce; the omnivorous Emydoidæ are more timid and inoffensive, and exhibit greater diversity in their mode of life; while the herbivorous Testudinina have the grave and confiding disposition of many of the Ruminants, though, owing to their slow motion, they have to trust solely to the strength of their covering for defence. But this coincidence, between the natural limits of families and the mode of life of their representatives, cannot be considered as a general rule obtaining throughout the animal kingdom, for among Fishes we find the most diversified habits in the same family. Among the Salmonidæ, as limited by J. Müller, who first recognized the natural boundaries of that family, there are voracious species, provided with strong, pointed teeth, and feeding exclusively upon living prey, such as the true Salmons and others which are entirely destitute of teeth and live upon decaying organic substances, such as the Coregonus. And yet these Fishes exhibit none of those striking differences which we are accustomed to consider as characteristic in the structure of carnivorous and herbivorous animals. Neither their alimentary canal, nor the large glands, nor the appendices pylorici connected with it, exhibit marked differences. This shows how cautious we ought to be in applying the mode of life of any animals as a test of their affinity.

CHAPTER THIRD.

NORTH AMERICAN GENERA AND SPECIES OF TESTUDINATA.

SECTION I.

GENERAL REMARKS UPON THE NORTH AMERICAN GENERA AND SPECIES OF TESTUDINATA.

In submitting the North American Testudinata to a renewed critical revision, my object is chiefly to show, that, among the representatives of this order, there are many genera on this continent which have thus far escaped the notice of herpetologists. It is no part of my plan to describe anew the species which have already been so well characterized and so fully illustrated by Major LeConte[1] and Dr. Holbrook.[2] It will be sufficient, for the object I have in view, simply to enumerate them, to characterize briefly those which may easily be confounded with others, and to insert such additional information as I may have collected respecting their eggs, their young, the variations of their colors, and their geographical distribution. With reference to the specific names of the North American Testudinata, it will be observed that I have not always followed the nomenclature now generally received. Whenever I was led to adopt other names than those in common use among modern herpetologists, it was only done with immediate regard to the inflexible law of priority; and I have availed myself, in this respect, of the information I could obtain from the correspondence of Linnæus with Dr. Garden,[3] of Charleston, who provided the great Swedish naturalist with so large a number of the animals of South Carolina, described in the Systema Naturæ.

I can hardly expect that the new genera I have characterized in this revision

[1] LeConte. North American Tortoises, in Ann. Lyceum Nat. Hist. of New York, vol. 3.

[2] Holbrook. North American Herpetology, Philadelphia, 1842. 5 vols. 4to.

[3] A Selection of the Correspondence of Linnæus and other naturalists, from the original manuscripts. By Sir James Edward Smith. London, 1821–2, 1 vol. 8vo.

of the North American Turtles should at once meet with a favorable reception. There are so many naturalists who look upon classification in general, and especially upon minor subdivisions, in the system of animals, merely as convenient devices to facilitate their study, that any distinction which in their estimation might be dispensed with is considered by them as objectionable, and must be so, according to their standard, which does not even admit that genera may exist in nature. However, as it is one of the objects of this work to show that genera are founded in nature, and that therefore the investigation of the genera and all the other natural divisions among animals require as careful and minute attention as that of species, I would add a few more remarks upon this topic, in order to anticipate the objections which may be raised against the subdivision of our Turtles into many distinct genera, and to illustrate their value by a comparison with the genera of one order of the class of Birds, — the Birds of prey, — with which the Testudinata may fairly be contrasted for their number, and the character of their peculiarities. In the first place, the groups called by Duméril and Bibron Thalassites, Potamides, Elodites, and Chersites (without entering again into the question already discussed,[1] whether they are families or groups of a higher order, or partly families and partly sub-orders) may stand a comparison with those groups among the Birds of prey which correspond to the old genera Vultur, Falco, and Strix, and which are now generally considered as families, though the differences among these Birds are certainly not so great, nor even of the same kind, as those which distinguish the Chelonii and the Amydæ. Indeed, the Vulturidæ, Falconidæ, and Strigidæ, when contrasted with one another, exhibit rather differences of form than of structure, whilst the peculiarities of the subdivisions of Testudinata cited above are rather differences of structure, which amounts to saying, that the differences of the latter bear the character of sub-orders, and the groups of Birds mentioned before differ in the manner of families. And yet nobody objects now any longer to the further subdivision of the Falconidæ, for instance, into such sub-families as Aquilinæ, Eagles, Buteoninæ, Buzzards, Falconinæ, Falcons, Accipitrinæ, Hawks, etc. This being the case, who does not perceive, that, if the groups Falconidæ, Vulturidæ, and Strigidæ are genuine families, they ought not to be compared respectively with a group like the Elodites, which embraces animals as different as the Cistudo, the true Emys, the Terrapins, the Cynosternum, the Chelydra, the Chelys, the Chelodina, etc.; but that, on the contrary, groups like these last, well circumscribed within their natural limits, truly constitute families also, corresponding, by their intrinsic value, to the families of the Strigidæ, Vulturidæ, and Falconidæ.

[1] Comp. Chap. 1, Sect. 2, p. 242–252.

This is the position which I am prepared to sustain by a further comparison. But even if the Thalassites and Amydæ were genuine families, and not sub-orders, this would not constitute an objection against subdividing them farther into minor natural groups, any more than the nature of the type of Falconidæ constitutes an objection against subdividing them into sub-families like those mentioned above, each of which contains still a number of distinct genera. Let us take, for instance, the group of our Terrapins, all of which are now generally referred to the genus Emys. It contains a great many species, which in the ultimate details of their structure differ as much, if not more, one from the other, than any two genera admitted among either the Falconidæ, the Vulturidæ, or the Strigidæ. I am willing to stake the correctness of my views on this whole subject upon one single case, taking as an example Emys rugosa (rubriventris,) mobiliensis, and concinna, (floridana,) which together constitute, in my opinion, a natural genus, and comparing them with any other natural group of species of this very same type, as for instance Emys scabra (serrata,) Troostii, and elegans (cumberlandensis,) taken together as another genus; or Emys picta, Bellii and oregonensis; or Emys geographica, and LeSueurii; or Emys concentrica, or insculpta, or marmorata, or reticulata, or guttata, or Mühlenbergii, which constitute singly as many natural genera. Any zoölogist, who, after a thorough comparison of the external characters and of the skeletons of the three first-named species, (Emys rugosa, mobiliensis, and concinna,) taking especially into account their skulls, their jaws, and their feet, and contrasting them with those of Emys picta and oregonensis, or of Emys insculpta, or any other of the groups of species just named, — any zoölogist, I say, who, having made such a comparison, would deny their generic difference, must be either blinded by prejudice against truth, or incapable by nature of applying himself to higher questions in Natural History. If this be true, it follows that among the Testudinata most of the genera contain very few species, and that this order affords an excellent opportunity to learn how generic characters may be ascertained, even without comparing many species.

These new genera differ in reality in the same manner as Vultur, Cathartes, and Gypaetos, or as Pandion, Aquila, and Harpyia, or as Milvus, Pernis, Buteo, and Circus, etc., differ one from the other. The same may be said of Chelydra, and Gypochelys, of Ozotheca and Cinosternum, etc. I need not enumerate here the characters of these genera, which are fully given hereafter in their proper places. Moreover, any one who would competently discuss this question, should examine specimens of all these species for himself, zoölogically and anatomically, when he will at least perceive that, in all our systematic works on Herpetology, the species of our Terrapins are either placed side by side without any reference to their true affinities, or grouped together according to characters which violate every natural relationship. At the same time, a renewed examination would afford ample opportunity, even to the most skeptical, to satisfy himself that the characters upon which these genera are founded have thus far, for the most part, escaped notice, and constitute a real addition to our knowledge, whatever be the view taken of the genera themselves.

As to the families adopted in this revision, they bear to one another exactly the same relations as all natural families have to one another in any natural order of the animal kingdom. They are consequently more readily distinguished by their habitus, as all natural families should be, that is to say, by their form, than are the artificial groups thus far called families among Testudinata by any special characters assigned to them. Why, according to present classifications, Chelydra and Cistudo, for instance, should belong together to the same family with our Terrapins, is not any more obvious than why the latter genus should not be referred to another group, the Testudinina, for instance; for there certainly are as striking differences, and even differences of a higher order, between Chelydra and Cistudo, or Chelydra and the common Terrapins, than between Vultures and Falcons. The same may be said of Ozotheca and Cynosternum taken together, when compared with either of them. And I cannot suppose that any naturalist will contend that different classes of the same great type of the animal kingdom should be classified upon different principles, however great the difference in the nature of the characters may be.

From what I have said in the opening of this section, it might be inferred that I consider the North American species of Testudinata as too well known to require much further attention and study. I am far from entertaining any such opinion. On the contrary, I consider, in general, an accurate knowledge of species as of such difficult attainment, that I do not yet venture upon sketching descriptions of our Turtles, as I understand that specific descriptions should be, even though I have already spent years in their investigation. What I offer in the following pages I wish to be considered merely as contributions towards a fuller illustration of this subject. It will still require long and patient studies before our Turtles are known as they ought to be, in order to draw a complete picture of the habits, growth, and variations of every species.[1]

As to the synonymy of the species,[2] it is not my intention to swell this vol-

[1] It is one thing to draw up perfect descriptions of species, and another and a very different thing to write mere diagnoses, or simply to point out the peculiarities by which closely allied species may be distinguished. Comp. Part I., Chap. 2, Sect. 6, p. 163.

[2] The older synonymy of all the Testudinata known at the time of the publication of his work is very learnedly discussed by J. D. SCHŒPFF, in his Historia Testudinum, Erlangæ, 1792, 1 vol. 4to. For the North American species consult Dr. Holbrook's North American Herpetology, or Duméril and Bibron's Erpétologie générale.

ume by publishing full quotations of all the works in which notices respecting our Turtles may be found. Every student, who may wish to make himself familiar with this branch of our science, will find ample references to all the works worth consulting in any general treatise on Herpetology. I have only alluded to the subject in detail where I had reasons to dissent from my predecessors.

SECTION II.

THE GENUS SPHARGIS.

The genus SPHARGIS was first pointed out by Merrem in 1820, under the name which is now generally adopted for it.[1] With the scanty materials I have on hand, I feel it the more difficult to draw up a description of the generic characters, as the habits of these Turtles are little known, and all the specimens I had an opportunity of seeing in America were adults, thus affording no opportunity for an appreciation of the changes they undergo with age. In the study of genera it is very important to compare young and adult specimens, as, from the differences they exhibit, it is generally possible to ascertain what constitutes generic characters, in contradistinction to family and specific characters. As far as I can judge from analogy, and by comparison with the genera of the Chelonioidæ, the following may be considered as generic characters.

The arch of the top of the skull is highest over the hind end of the brain-box, and grows narrower and lower thence forward to the eye orbits. The upper surface falls from over the hind end of the brain-box backward; it is depressed over the front end of the brain-box. The frontal region falls from the hind end forward. The upper edge of the opening of the nasal cavity is nearly on a level with that of the eye orbit. The intermaxillaries rise considerably above the level of the lower edge of the eye orbit; they are very thick above, and taper to a sharp edge below. The edges of the notch of the front end of the alveolar wall of the mouth meet the edge of the lateral notch of each side, on the maxillaries, near the suture with the intermaxillaries. The three notches occupy the alveolar edge of that part of the mouth which underlies the nasal cavity. The horizontal alveolar surface of this part of the mouth rises steeply forward; it is

[1] In 1828, Fleming called it Coriudo, in imitation of the name Testudo; in 1829, LeSueur, in Cuvier's Règn. Anim., proposed the new name Dermochelys for it; in 1830, Wagler introduced still another name, Scytine, in the plates to his Nat. Syst. der Amph., a few copies of which bear that lettering; but he finally adopted LeSueur's name, changing it however to Dermatochelys.

very small, being formed on a small ridge projecting inward. From this region backward the alveolar edge is sharp, and rises constantly, and the horizontal alveolar surface widens to its hind end, which slants forward, however, to the union with the palatines. The alveolar wall of the mouth is turned inward at the lateral notch on each side, and outward at its hind end, and thus curves irregularly. The vomer descends just back of the symphysis of the jaw, so as to make behind it a deep inverted pit, into which the pointed end of the lower jaw fits. The palatines have each two distinct planes, one horizontal and continuous with the horizontal alveolar surface, the other raised toward the vomer; the former begins in front at a point, and widens backward; the latter rises highest and steepest at its front end. The passages from the nasal cavity to the mouth are very large. They lie on each side of the front end of the vomer, between it and the maxillaries and the end of the palatine. The lower jaw is highest near the articulation and the symphysis; its upper and lower edges draw near each other forward till near the front end, where the alveolar edge rises suddenly to a strong, sharp projection, and the lower edge curves down a little. The alveolar edge is sharp. The outer surface, at the symphysis, curves outward in passing from the point down to the lower edge.

There are no scales over the skin. None of the fingers project free, and thus none have nails. The epidermis over the jaws is not thickened into a horny sheath. Upon the ossified derm, the epidermis is very thin. On the neck and limbs and tail, the skin is thick and leathery, and its epidermis hard and compact.

The prevailing opinion among herpetologists is, that there exists only one single species of Sphargis, which is said to occur along the shores of Eastern Asia, especially about Japan, in South Africa, about the Cape of Good Hope, and in the Atlantic, chiefly in the West Indies and the southernmost coasts of the United States, and in the Mediterranean. But, in my opinion, it is not yet by any means clearly proved that the specimens observed in these different stations truly belong to the same species. Our museums are still so indifferently provided with representatives of this genus, that no sufficient comparison has thus far been made between individuals obtained in different parts of the world; and as long as it can be shown that the Loggerheads, the green Turtles, and the shell Turtles of the Atlantic differ from those of the Pacific, mere descriptions, without the additional evidence of direct comparison, are insufficient to settle the question of the specific identity or difference of the leather Turtles of the two great oceans. It is true that Temminck and Schlegel assert that the Sphargis of Japan[1] is iden-

[1] SIEBOLD, (Ph. Fr. de) Fauna japonica. Chelonii elaborantibus Temminck et Schlegel, Lugduni Batavorum, 1833, fol. This work contains important remarks upon the anatomy of the Testudinata.

tical with that of Europe; but, in matters relating to the specific distinction of Turtles, I am not willing to take as evidence the assertion even of such distinguished zoölogists, because they have described several North American species as identical, which I know not only to be distinct species, but even to belong to distinct genera.[1] There can be no doubt, however, that there is only one species of Sphargis in the Atlantic and in the Mediterranean, which is universally known as SPHARGIS CORIACEA, *Gray*.[2]

The first author who mentions this species is Rondelet, who, in his work *de Piscibus*, published in 1554, describes and figures it, under the name of Testudo coriacea sive Mercurii, from specimens caught in the Mediterranean. It has since been noticed occasionally in the Mediterranean, and upon the Atlantic coast of France and of England; but in all I cannot make out more than nine instances[3] of its occurrence in the waters of Europe. Nor has it ever been seen to lay its egg and multiply in that part of the world, while it is very common in the warm parts of the Atlantic Ocean, especially along its American shores. It breeds regularly every year in the spring, on the Bahamas, on the Tortugas, and on the coast of Brazil. It occurs less frequently, already, along the coast of Florida; it is caught occasionally on the coast of Alabama, Georgia, and South Carolina, and only accidentally visits the more northern shores of the United States. It has, however, been noticed in the Chesapeake Bay, off Sandy Hook, and in Long Island Sound. One specimen, taken in Massachusetts Bay in 1824, is now preserved in the Boston Museum. In 1848, I obtained one specimen myself, caught about Cape Cod by Capt. N. Atwood.

From this critical examination of the localities where this species is found, and

[1] Ozotheca odorata and Cinosternum pennsylvanicum, Xerobates carolinus and Chelonoidis tabulata.

[2] This species exemplifies clearly a point in zoological nomenclature which seems hardly yet understood, though it has been frequently debated before. Many naturalists still believe, that the authority attached to the systematic name of a species indicates the discoverer or first describer of such a species. Nothing can be more remote from the truth. The name of a naturalist, attached to the scientific name of an animal, indicates only that he is the first who employed that binominal appellation to designate such an animal. In this case Rondelet was the first who described the species, which he calls TESTUDO *coriacea* sive Mercurii. When Merrem recognized that it constitutes a genus for itself, he called the genus SPHARGIS, but wantonly changed the specific name to Sphargis *mercurialis*. Had he retained the specific name under which Rondelet described it, it would have been called Sphargis coriacea, *Merrem*, as the generic and specific names together constitute the systematic name of any animal. As it happened, J. E. Gray was the first to connect the generic and specific names, which must take precedence over all others, and so the species is for ever to be called Sphargis coriacea, *Gray*, even though Gray neither established the genus nor described the species first.

[3] Three times in the sixteenth century recorded by Rondelet; once at Cette, mentioned by Amoreux; once at the mouth of the Loire, recorded by Delafond; twice on the coast of Cornwall, recorded by Borlase; once on the coast of Dorset, recorded by Shaw; and once on the eastern coast of Italy, recorded by Schweigger.

from its frequence in some parts of the Atlantic Ocean, whilst it is only met with accidentally in others, it is plain that the West Indies is its home, and that it is not indigenous to Europe, since in three centuries it has not been observed more than nine times in Europe, whereas it is seen at all seasons about the Bahamas.[1] This conclusion is strengthened by the fact that it is less and less common as we recede from the Floridas northward; though from time to time it is carried north by the Gulf Stream, and cast ashore along the Southern and Middle States, and more rarely as far north as Cape Cod. It therefore becomes highly probable, that the specimens seen in Europe, on the coasts of England and France, and in the Mediterranean, had followed the Gulf Stream across the Atlantic, and finally landed in regions very distant from their native seas. This fact is highly important with reference to the question of the identity of the Thalassochelys Caouana, found also on both sides of the Atlantic.

Judging from the figures of the eastern Sphargis published by Ph. Fr. von Siebold in his Fauna japonica, taking especially into consideration the form and relative size of the head, the emarginations of the jaws, and the relative size of the fins, I am inclined to believe that there exists a second species of Sphargis in the Pacific Ocean, along the shores of Asia, which wanders southwards, with the Asiatic shore currents, to an extent not yet ascertained. It is also reported by Temminck and Schlegel that Sphargis is found about the Cape of Good Hope, and that young specimens collected in that region, by Dr. van Horstok, are preserved in the museum at Leyden. It is further stated by them, that the figures published by Wagler are drawn from a young specimen from the Cape of Good Hope, presented to the museum of Münich by the museum of Leyden. This being the case, the question at once arises, whether these figures represent truly the same species as that which occurs in the waters of the Atlantic and in the Mediterranean, or whether there exist two other species of Sphargis, besides that of the Atlantic, one of which would be peculiar to the Asiatic shores of the Pacific Ocean, and the other to the seas bathing the southern extremity of Africa. With the great powers of locomotion which these Turtles possess, it is, however, also possible that Asiatic specimens find their way to the Cape, and hence to the West Indies; in which case the same species would be found wandering through all the oceans. But nothing short of a direct comparison of a series of specimens from each locality will settle this question.

[1] Supposing the American specimens to be distinct from the European, LeSueur distinguishes two species of Sphargis, and calls the American, Dermochelys atlantica. The young has also been described as a distinct species, at first called Testudo tuberculata by Pennant, and afterwards referred to Sphargis, as Sph. tuberculata, by Gravenhorst. For more special references to the authors mentioned above, consult Duméril and Bibron, Erpét. génér., Holbrook's N. American Herpet., and Canino's Fauna italica.

SECTION III.

THE GENERA AND SPECIES OF CHELONIOIDÆ.

Three well marked genera, belonging to this family, occur along the coasts of the United States; namely, Chelonia, Eretmochelys, and Thalassochelys. The most important generic characters thus far observed relate to the structure of the mouth, and indicate much difference between them, in the manner of eating, and, perhaps, also in the kinds of plants upon which they feed. In CHELONIA the jaws act like straight-edged shears, cutting from behind forward; the mouth is bluntly curved about the front end; the outer alveolar edge of the lower jaw falls from the angle forward till just at the end, where it rises to a small, sharp projection; the bill along this edge is deeply serrated; its teeth act against sharp ridges, which cross, from above downward, the inner vertical surface of the bill of the upper jaw. In ERETMOCHELYS the jaws are drawn out forward, as it were, and the mouth is narrow and long; at the front end the cutting edges of the two jaws project toward one another beyond their general level, so that as the jaws close, these edges approach each other first at their front and hind ends; the cutting edge of the lower jaw is short, as the upper surface is rounded for some distance in front of the angle; the cutting edges are sharp, but not serrated. In THALASSOCHELYS the jaws are prolonged toward one another at the front ends into strong, pointed beaks, but not drawn out forward as in Eretmochelys; as the jaws close, they approach one another first at the front and hind ends; the alveolar edge of the lower jaw is deeply concave, and rises higher at the point than at the angles; the alveolar edge of the upper jaw rises on each side of the beak, and curves downward under the eye; the alveolar edges are blunt, and not serrated.

I am not able to express an opinion upon the value of the genera Halichelys and Lepidochelys, as I have not enjoyed an opportunity of examining myself the species upon which they are founded.[1] But I can state that there occur, among the fossils of the reefs of Florida, remains of a large marine Turtle which differs generically from the other species found alive about the reefs. I am indebted for a splendid skull of this Turtle to one of my pupils, Mr. Theodore Lyman, of Boston; and I have obtained myself other fragments of the

[1] These genera were proposed by Fitzinger in his Systema Reptilium; Halichelys for the Caretta atra, *Merr.*, Chelonia atra, *Auct.*, and Lepidochelys for the Chelonia olivacea, *Esch.*, of the Pacific.

skeleton from Cape Sable, all of which I shall describe on another occasion. It is possible that this Turtle is the American representative of the Halichelys nigra of Fitzinger, founded upon the Caretta nigra, *Merr.*, which is said to occur on the Atlantic coasts of Europe and Africa. As to the genus Cimochelys, proposed by Owen for Chelonia Benstedi, and afterwards abandoned by himself as a generic type, I am inclined to consider it as well founded, though, judging from its form, I am not satisfied that it is a true Chelonioid.[1]

In the genera of this family the whole body is covered with a scaly epidermis, and on the head where the skin fits close to the bones, on the shield, and on parts of the wings, the scales are large and distinct. On the upper surface of the head there is one large median scale, surrounded by a row of more or less numerous smaller scales, one or two pairs of which reach down from that row to the nose. A field of large scales covers the cheek. A thick, horny sheath always envelops the alveolar surface of each jaw, the wide space of the front part of the roof of the mouth before and on each side of the opening of the passage from the nasal cavity, and the whole upper surface of the lower jaw about the symphysis. Just back of the bill on the lower jaw there is a large scale. On the ends and front edges of the limbs, the scales are large. On the inner edge of the wing there is a row of four or five scales, which seem to correspond to the quill feathers of a bird's wing. The scales on the shield are arranged in regular rows, namely, one row all round the outer edge, one row along the median line above, one row on each side of the latter covering the costals, and four rows on the plastron, one just within the marginal row, and another between this last and the median line, on each side. The marginal row terminates, in front, by an odd scale, and behind, by the meeting of a pair. The number of pairs in this row varies somewhat in different specimens; in Chelonia and Eretmochelys there are, however, usually twelve pairs; in Thalassochelys there are thirteen. The odd scale at the front end of this row is very broad, several times broader than long. The number in the row over the median line is four; in the row on each side of this last, four or five, four in Chelonia and Eretmochelys, and five in Thalassochelys. The outside rows of the plastron consist each of four, the inner, two rows of six scales each; besides, there are some large scales under the hind part of the shoulders, and sometimes one or more are interposed at either end of the median line of the plastron.

If we now consider the American genera separately, they may be characterized in the following manner.

[1] Compare my remarks about this species, p. 339, note 3, at the close of the note.

I. CHELONIA, *Brongn.* (*Fitz.*)

The genus Chelonia, when first separated from Testudo by A. Brongniart, included all the marine Turtles, even Sphargis. It was next limited to the Chelonioidæ proper, and in this extension it corresponds exactly to Merrem's genus Caretta. Now it embraces only the green Turtles. It was first restricted to its present limits by Fitzinger.[1]

The head of this genus, thus limited, is high, and continues so forward to the frontal region, where the upper surface descends steeply to the nose. From the nose down, the outer surface of the end of the bill of the upper jaw is curved outward; but it is turned back as far below as above. The mouth is long, but broadly curved at the front end. The alveolar edge of the bill of the upper jaw is straight, or slightly concave at the sides, and slightly notched at the front end; it is sharp, but not serrated. The vertical inner surface is broadest at the hind end, and narrows thence forward till at the front end a small pit in the palate again widens it. The outer edge of the horny roof descends from behind forward to the pit above mentioned; the surface within descends from this edge inward to a ridge, which ridge has a deep depression at the symphysis, is most prominent on each side of the depression, and decreases thence backward. The space between this ridge and the outer wall is a furrow, into which the lower jaw fits, as well as into the pit in front. Within this ridge the surface is broad, and also has a depression at the symphysis; this surface descends to a small ridge at its inner edge. The lower jaw is highest at the angle, and falls thence forward, but at the front end there rises a small, sharp projection. The alveolar edge of this jaw is deeply serrated. Within this edge is a furrow, corresponding to the ridge of the upper jaw, which is widest at the symphysis, and there divided by a transverse ridge; it is deepest on each side of that ridge, and fades out shortly before reaching the angle of the jaw. The ridge on the inner side of this furrow does not descend from behind forward as fast as the outer alveolar edge, and at its front end is as high as the latter; it rises at the symphysis to a sharp tooth, which is, however, almost entirely formed from the horny covering. The ridge vanishes with the furrow backward. Its inner surface descends a little way, in one slope, and then more steeply to the attachment of the tongue. The outer alveolar edge of this jaw is serrated as far back as the hind angle of the jaw. When the mouth is closing, this edge approaches the alveolar

[1] Syst. Rept. 1843. It is adopted by J. E. Gray, in the same extent, Cat. Brit. Mus. 1844, and by Tschudi, in his Fauna peruana, 1845; but Tschudi proposes to change the name to Euchelonia.

edge above, first at the hind end, and thence forward successively; but, as the front tooth is longer than the others, it reaches the plane of the alveolar edge above before those which are nearest to it on each side. The whole horny surface of the mouth is rough, and its ridges sharp and pointed. As the head is high and narrow, the upper surface is small, and the cheeks large; consequently the field of scales is small on the top of the head, and those on each side large. The row of scales encircling the large scale in the middle of the skull is regular, and consists of seven scales. This row reaches partly down on the sides; below them there is a field of from fifteen to twenty scales on the cheeks, not counting the very small ones about the articulation of the jaws. In front of the circle of seven scales, there is one pair of long ones, which reach down to the nose.

The body is oblong, broad across the middle, not keeled or flattened above. It has a narrow marginal rim. The scales are everywhere thin and flexible, and meet edge to edge, being nowhere imbricated.

Thus far, only two well characterized species of this genus have been noticed; the common green Turtle of the Atlantic Ocean, and the mottled Turtle of the Pacific. At least, I can only distinguish them in this way; and I must call in question the statements which report Chelonia Mydas, as found in the Indian Ocean, the Red Sea, and China, as well as those according to which the mottled Turtle, Chelonia virgata, would also occur in the Atlantic.[1]

CHELONIA MYDAS, *Schw.* The green Turtle of the Atlantic[2] is nowhere so common as about Ascension, where the largest numbers are caught. It is very common on the Bahamas and among the West Indies, especially at Cayman's Island, where large numbers breed; also in the Bay of Honduras and Campechy, and along the coasts of Guiana and Brazil. It also inhabits the coasts of Florida, and of the southern United States bordering upon the Gulf of Mexico; but it is seldom found as far north as the thirty-fourth degree of northern latitude, and is rarely caught as far north as Sandy Hook. It is never seen along the coast of New

[1] It is not surprising that seamen should mistake the two kinds of green Turtles which occur in the Atlantic and in the Pacific, as they are closely allied, and vary both to some extent in color, so that the radiated variety of the green Turtle (Chel. Mydas) is often darker and more extensively tinged with chestnut brown than the Pacific species, (Chel. virgata,) which is occasionally quite as green as its Atlantic representative. Statements respecting the geographical distribution of these species should therefore be sifted with the utmost care, as it is probable that the indications of the presence of Chelonia virgata in the Atlantic are owing to a confusion in labelling the specimens.

[2] The names most frequently applied to this species are Testudo Mydas, Chelonia Mydas, Testudo viridis, Chelonia viridis, Caretta esculenta, and Chelonia esculenta. For fuller references, see Duméril and Bibron, Erpét. génér., and Dr. Holbrook's N. Amer. Herpetology.

England, nor has it ever been observed upon the shores of Europe. Along the coast of Florida, it approaches the shore in the early part of the summer to deposit its eggs in the sand; but the statement of DeKay, that they are hatched in the course of two or three weeks, is certainly incorrect, as no Turtle develops so rapidly. The shortest period of incubation of Turtles' eggs I have ascertained to be about seven weeks. Though regularly brought to our markets in the season, I have failed to obtain mature eggs of this species, and young recently hatched; but Gravenhorst[1] gives a good description of the young, and Audubon a very interesting and full account of the breeding.[2] This species is also reported to occur along the Atlantic coast of Africa, from the Cape of Good Hope to the Cape de Verd Islands; but I have had no opportunity of comparing specimens from these regions. Nor can I give an opinion from personal experience respecting the green Turtles of the Red Sea and of the Indian Ocean. Tschudi states that Chelonia Mydas occurs on the coast of Peru; but, as he does not say that he compared it with Atlantic specimens, it may be the following species.

CHELONIA VIRGATA, *Schw.* Without entering into the question of the identity of the green Turtles all over the immense range of the Pacific Ocean,[3] I can state that there occurs, along the coast of California, a species of green Turtles which is entirely distinct from that of the Atlantic, by its more elevated and more arched back, and by the emargination of its sides over the hind limbs. Besides heads and paddles, I am indebted for two perfect specimens of this species to my friend, Th. G. Cary, Jr., of San Francisco, to whom I already owe so many scientific treasures from California. I have thus been able to compare it with the Chelonia Mydas of the Atlantic, from which it certainly differs as species. As far as I know, this is the first time that sea Turtles are mentioned from the western shores of North America. Mr. Cary informs me that they are found along the whole southern coast of California. The only doubt I have left in my mind respecting this Pacific green Turtle is, whether it is identical or not with the species described from Malabar and the East Indian Ocean.[4]

[1] Deliciæ Musei zoologici Vratislaviensis, Lipsiæ, 1829, fol.

[2] Ornith. Biogr. II. p. 370.

[3] Green Turtles are mentioned from the Galapagos, from the whole range of the Polynesian Islands, from New Holland, from the Philippine and Sunda Islands, from the whole eastern coast of Asia as far north as Japan, from the Red Sea and the Indian Ocean, and from the eastern coasts of Africa. But, whether they belong to one and the same species or not, remains to be ascertained by direct comparisons.

[4] These species are described by Duméril and Bibron under the names of Chelonia maculosa, *Cuv.*, and marmorata, *Dum.* and *Bibr.* Cuvier's Chelonia lacrymata is referred by them to Chelonia maculosa. I am inclined to admit that my California specimens are identical with Chelonia maculosa; but I question the specific difference of Chelonia maculosa, *Cuv.*, and Chelonia virgata, *Schw.*, and therefore refer them under the older name, Chelonia virgata, *Schw.* For reference to these species, see Duméril and Bibron, Erpét. génér., vol. 2, p. 541–546.

II. ERETMOCHELYS, *Fitz.*

The genus Eretmochelys was first noticed by Fitzinger[1] as distinct from Chelonia. The head is low; its upper surface is broader than in Chelonia, and its descent to the nose less. The mouth is long and narrow. The sides of the upper jaw are compressed, and the front end drawn out forward and downward, so that its lower edge is in advance of the nose, and below the general plane of the edges of the sides. The front end is narrow and blunt, and keeps about the same width from the nose down to the lower edge, which, therefore, is not pointed, but like the curved edge of a chisel. The edges of the sides are nearly straight. The inner vertical surface of this jaw is broad at the hind end, and narrows thenceforward for the greater part of its length, but widens for a short distance to the front end. This widening at the front end is not caused by a pit-like depression in the horny roof, but by a gentle rise of the latter at the symphysis. The surface of the horny roof falls from without inward to a ridge, which is divided at the symphysis by a deep transverse depression; it is most prominent on each side of this depression, and decreases thence backward; from the front end backward it approaches the outer wall for some distance, and then again recedes from it. The furrow between this ridge and the outer wall is widest and deepest at the front end; it narrows to about midway, and then widens again to the hind end; but this latter widened part is only a slight depression. Within the ridge, the surface rises to its inner edge; it is as broad at the symphysis as the furrow; it decreases backward, and vanishes at the hind end. The lower jaw is also long and narrow; it is drawn out forward and upward at the front end; the alveolar edge of this end is not pointed, but curved, and is as high as the angle of the jaw. The alveolar edges at the sides are nearly straight; they are not sharp for the whole length, but thick

[1] In his Systema Reptilium, published in 1843. In 1844, J. E. Gray, in the Cat. of the Brit. Mus., adopted it, but changed the name to Caretta. On general grounds of fitness, this name would be acceptable, as it is derived from the vernacular name of the tortoise-shell, the *caret* of the French, and the species which produces this valuable article is the type of the genus. It might also be said, that, as Merrem applied the name of Caretta to all marine Turtles in the same sense as Brongniart had applied to them that of Chelonia, when it became necessary, in the progress of science, to subdivide the sea Turtles into several genera, the name of Caretta ought to have been preserved for one of the new genera, as well as that of Chelonia. But, the naturalist who first noticed these generic differences had the unquestionable right to use his own discretion in adopting any well-framed name he chose for these genera; and as Fitzinger selected that of Eretmochelys for the Turtle which produces the tortoise-shell, that name must now be retained, and no one has a right to change it hereafter. Duméril and Bibron consider this genus merely as a sub-genus of their Chelonia, which includes all the marine Turtles, except Sphargis.

and blunt for some distance in front of the angle. The lower surface of this jaw is turned down, at its front end, below its level at the sides. The furrow corresponding to the ridge of the upper jaw is broad at the symphysis; it is deep below the outer edge, and short, reaching back to where the alveolar edge becomes blunt; it narrows from the symphysis backward to a point, and at its inner edge rises to a small ridge. The surface within the ridge descends steeply and in one slope to the attachment of the tongue. While the mouth closes, the cutting edges approach each other first at the front and hind ends. The cutting edges are sharp, but not serrated, and there are no teeth or furrows on any part of the horny surface of the mouth. The horny bill is stiff, and projects unusually far beyond the bone of the jaw.

The arrangement of the scales on the upper surface of the head is very similar to that of Chelonia, excepting that the row of seven scales, which encircles the large middle scale, is more on the top of the head, and extends less down on its sides. Two pairs of scales reach from this row forward to the nose. The field of scales on the cheek, like the cheek itself, is small, consisting in number of from seven to ten scales.

The body is long, narrow, and oval. The marginal rim descends steep and wide over the shoulders, and flares out wide only about the hind end of the body. The scales on the shield are thick and stiff, forming hard plates (the tortoise-shell of commerce); they are pointed behind, and imbricated, each one overlapping the one next behind. The large scales on the inner edge of the front limbs are narrower at their outer than at their inner ends, a character which seems to be connected with the manner of folding back the limbs. The tortoise-shell is obtained from the species of this genus.

Modern herpetologists admit, in this genus, only one single species,[1] which is believed to be common to the Atlantic and the Pacific Oceans. Having had ample opportunities of comparing specimens from the West Indies with a series of young and adults from the South Seas, preserved in the museum of the Essex Institute in Salem, I have satisfied myself that the shell Turtles of the Pacific Ocean differ specifically from those of the Atlantic. Specimens from the West Indies having first been described under the name of Testudo imbricata, under which both are now confounded, this specific name unquestionably belongs to the Atlantic species.

ERETMOCHELYS IMBRICATA, *Fitz.*[2] This species is common in the West Indies, and

[1] Though synonymous with the following species, Chelonia Pseudo-Caretta of Lesson is generally considered as a nominal species, whilst Kuhl's Chelonia multiscutata is unquestionably a monstrosity.

[2] This species is more generally known under the names of Testudo imbricata, Chelonia imbricata, Caretta imbricata. See, for references, Dr. Holbrook's N. Am. Herp., and Dum. and Bibr. Erpét. génér.

extends all over the Gulf of Mexico, and along the coasts of the southern United States. I have seen it alive at Key West (Florida); specimens were also brought to me from that locality by my young friend, Theodore Lyman, of Boston. It is occasionally seen along the coasts of Mississippi, and all along the coasts of Texas and Mexico. It is frequent around Yucatan, in the Little Antilles, and especially about Jamaica and the Cayman Islands; it extends also along the coasts of Guiana and Brazil. Whether the specimens observed by Tschudi, on the coast of Peru, belonged to this or the next species, I am unable to state; nor do I know whether it occurs on the Atlantic coast of Africa.

ERETMOCHELYS SQUAMATA, *Ag.*[1] This species is as common in the Indian and Pacific Oceans as the preceding in tropical America. It has been observed by Siebold on the coasts of Japan; it is already more common in the Chinese waters; it is frequent about the Sunda Islands, New Guinea, and Borneo, and in the Indian Ocean about the Seychelles. Duméril and Bibron quote it from Isle Bourbon, and Lesson from the low islands of the Pacific.

Young specimens of Eretmochelys imbricata and squamata are very similar, heart-shaped; but while Eretmochelys squamata preserves this form to old age, the adult Eretmochelys imbricata is more elliptical. The squamation is also very similar; but while Eretmochelys squamata has distinct, though small horny plates upon the neck, Eretmochelys imbricata has none, and exhibits only minute folds in the skin. The keels upon the large epidermal scales of the shield are much more developed in Eretmochelys squamata than in Eretmochelys imbricata. There is one median ridge upon the scales of the vertebral row from the first scale to the last; in the Atlantic species, only upon the last four scales. There are, besides, converging ridges upon all these median scales in Eretmochelys squamata, and only upon the last two in Eretmochelys imbricata. In Eretmochelys squamata the scales of the costal row exhibit prominent ridges, arising from the angles they form with the marginal scales, and extending to the posterior free angle of each scale, of which no trace is observable in Eretmochelys imbricata, neither in young nor in adult specimens. These ridges are intersected by the lines of growth, and have the appearance of a projecting chain. The ridges upon the middle rows of the sternal scales are much more prominent in Eretmochelys squamata than in Eretmochelys imbricata. The projecting ridges of the scales of the mar-

[1] I adopt, as the specific name of this Turtle, one of the synonyms referred by Linnæus to the preceding species. I select this in preference to several others, such as Caretta nasicornis, *Merr.*, Chelonia multiscutata, *Kuhl.*, Chelonia Pseudo-Caretta, *Les.*, or Testudo macropus, *Walb.*, because it is the oldest name applied to a Turtle supposed to be identical with Eretmochelys imbricata, and also because the name *squamata* is particularly appropriate for a species from which the tortoise-shell is obtained.

ginal row form more prominent points in Eretmochelys imbricata than in Eretmochelys squamata. Less marked differences are further observed in the form of the different scales, all of which coincide to show that the Eretmochelys of the Atlantic and of the Pacific Oceans are distinct species.

III. THALASSOCHELYS, *Fitz.*

The genus Thalassochelys was established by Fitzinger, in his systematic arrangement of the Testudinata.[1] The head is low, broad, and flat on top; its upper surface descends but little forward, and the nose is placed high, which is made necessary by the height to which the roof of the mouth is raised under it. The mouth is broad; the jaws are prolonged at the front end toward one another to strong, pointed beaks, but they are not drawn out forward, as in Eretmochelys. The outer edge of the upper jaw rises on either side of the pointed beak, and then curves down under the eye. The vertical inner surface of this jaw is very broad at the hind end; it narrows forward to about midway, and then again widens to the front end, where it is broadest. The horny surface of the roof of the mouth is high at the hind end; it curves down thence to about midway, and then rises again to the front end, where it is highest. This curve from end to end is uninterrupted at the outer edge; but from this edge the surface descends inward and backward for some distance, then suddenly rises, like a step in a staircase, and then again curves up gradually inward and backward to its hind edge. The part in front of the step can hardly be called a furrow, or its inner edge a ridge, for it descends gently, and comprises about half of the whole horny roof; there is a depression in its inner edge at the symphysis; on either side of this depression, it has more than half the width of the whole horny surface. It narrows backward, and before reaching its hind end unites imperceptibly with the part in front of the step. It has a pit at the front end of the symphysis. The lower jaw is high at the angle, and at the front end is drawn out to a long, strong point, which is still higher than the angle. The outer alveolar edge, from the angle to the point, is deeply concave. The alveolar surface descends steeply inward, is very broad at the symphysis, and narrows backward to the angle. At its inner edge it rises to a small ridge, and from the crest of the ridge it descends steeply and on one

[1] Entwurf einer Syst. Anordn. der Schildkröten. Ann. des Wiener Museums, 1836, 4to. It is maintained in the Syst. Amph. of 1843, and adopted by J. E. Gray in the Cat. Brit. Mus. 1844, under the new name of Caouana. Duméril and Bibron consider this genus simply as a sub-genus of Chelonia.

slope to the attachment of the tongue. The cutting edges are blunt and not serrated, and the horny surface of the mouth generally smooth.

The body is very broad across the shoulders, and short from the scapular arch to the front end. The marginal rim flares out broad at the hind end, and continues so forward nearly to the shoulders. The curve, from side to side over the upper median line of the body, is somewhat flattened. There is a keel along the median line. The scales are everywhere thin and flexible. The head is so flattened above that the circle of scales around the large median one on top is almost entirely upon the upper surface. The scales of this circle are less regular and more numerous than in the other genera, about twenty in number in the specimen examined. There are two pairs between this circle and the nose. The field of scales on the cheeks is small, but the number is about the same as in Chelonia, namely, from fifteen to twenty. There is one marked peculiarity in the arrangement of the scales on the shield, namely, an addition of one scale to the row covering the costals, on each side of the median row, on the upper surface. The additional scale is small, and situated at the front end of its row. In the specimens examined there are twenty-seven scales in the marginal row, which is one pair more than in the specimens of the other genera which could be compared.

This genus numbers thus far only two species;[1] one of which is found in the Atlantic and in the Mediterranean, and the other in the Pacific Ocean.

THALASSOCHELYS CAOUANA, *Fitz.* This species is very common along the American coasts of the Atlantic, from Brazil to the southern United States.[2] It is the most common species of Chelonioid found upon the coasts of the United States, as it is even frequent in latitudes where other species occur only accidentally. It breeds usually as far north as the thirty-second degree of latitude, on the coast of South Carolina, whence I have obtained large numbers of eggs, through the kindness of Hon. J. Townsend, and occasionally even as far north as North Carolina and Virginia. It may be seen along the whole coast of the more southern States during the breeding season, in Georgia, Florida, Alabama, and Mississippi. From Florida I have obtained eggs in every stage of development,

[1] J. E. Gray enumerates a third species, Cat. Brit. Mus., under the name of Caouana elongata, of which, however, he has only seen one shield. I must leave it doubtful whether the species of the Pacific, the Chelonia olivacea of Eschscholtz, (Chelonia Dussumieri, *Dum.* and *Bibr.*,) truly belongs to this genus, or is to be considered as the type of a distinct genus, Lepidochelys, as Fitzinger thinks.

[2] Its most common names are Testudo Caretta, Chelonia Caretta, Testudo Cephalo, Chelonia Cephalo, Caretta Cephalo, Testudo Caouana, Chelonia Caouana, Caretta Caouana, Caouana Caretta, etc. For references, see Dr. Holbrook's N. Am. Herp., and Dum. and Bibr. Erpét. génér. With the exception of Valenciennes, all zoölogists consider the European and the American Caouana as identical.

through the kindness of Mr. I. W. P. Lewis. It is found everywhere in the Gulf of Mexico and among the West India Islands, from the Bahamas to Trinidad, and further south along the coast of Guiana and Brazil. The many specimens I have examined leave no doubt in my mind that there exists only one species of this genus in America. But the question now arises, whether the Caouana of the Mediterranean is identical with that of America. Unlike Sphargis, the Caouana is common in Europe; it breeds there as well as in America, and unquestionably is at home in the Mediterranean. It would, therefore, be highly important to ascertain whether the American Caouana ever crosses the Atlantic. This is the more desirable, as Valenciennes has described the European Caouana as a distinct species, under the name of Chelonia Pelasgorum.[1] The more extensive range of this species northward along the coast of the United States, might explain its frequence in the Mediterranean, if the Chelonia Pelasgorum is not a different species. If it is distinct, the American species may yet, as do some of the American Birds, occasionally appear in the Mediterranean, and have been confounded with the European species. There are here four possibilities, which render renewed investigations and direct comparisons of European and American specimens very desirable. Either the European Caouana has come from America, following the Gulf Stream, in larger numbers than Sphargis does, and, settling in Europe, has become as numerous there as it is on the other side of the Atlantic, the reverse course being impossible on account of the direction of the Atlantic currents; or, this species, though identical in Europe and in America, has originated separately in both hemispheres; or, a closer comparison may show that the European and the American are distinct species; or, finally, though the European and the American were distinct species, the American may, nevertheless, occasionally visit the shores of Europe, as Sphargis does. There are other reasons which render a direct comparison of the Turtles of this genus from different oceans very desirable. Temminck and Schlegel state,[2] that the Chelonia olivacea is the same species as the Caouana, which may wander as far as New Holland and Japan. Such an ubiquitous occurrence of this species can hardly be admitted without more stringent evidence than that alluded to by them, especially when such a mode of distribution runs directly against the well-known direction of the oceanic currents.

Audubon states, that the Loggerhead, Caouana, feeds mostly on large conchshells. The young of this species, about which more may be found in the following section, are figured in Pl. 6, fig. 13 to 32, and the eggs, which are more fully described in the Third Part of this work, are represented in Pl. 7, fig. 30.

[1] Expédition scientifique de la Morée, Paris, 1840, fol.

[2] Fauna japonica, Chelonii, p. 26.

A large species of this family has been found by Professor Francis S. Holmes, of Charleston, in the tertiary deposits of South Carolina. Other specimens, from the miocene of New Jersey, have been described by Dr. J. Leidy under the name of Chelone grandæva, and others still, from the green sand, under the name of Chelone ornata;[1] but, whether they belong to the genus Chelonia as now limited, or to Thalassochelys, or to Eretmochelys, is not yet ascertained.

SECTION IV.

COMPARISON OF THE GROWTH OF THE CHELONII WITH THAT OF THE AMYDÆ.

The investigation of the general form of young Emydoidæ, and a minute comparison with the adults,[2] has led to the result, that all Emydoidæ exhibit, when hatching, a circular form, which grows more and more elliptical with advancing age. This law of morphological development does not hold good for sea Turtles. On the contrary, they are much longer in proportion to their width, when hatching, and then grow gradually broader. The upper shield of Thalassochelys Caouana, when hatching, has a longitudinal diameter of $0^m,045$, and a transverse diameter of $0^m,035$; a fortnight after, the relation is $0^m,046$ to $0^m,038$; after twenty-one days, $0^m,050$ to $0^m,042$; and in the half grown, $0^m,275$ to $0^m,250$. This clearly shows a change from a longer to a broader form, just the reverse of what is observed in the Amydæ. How is this to be understood? Is the development of the form just the opposite in these two sub-orders; or is it, perhaps, that the Amydæ have already run through the form of the Chelonioidæ while in the egg, and appear now round when hatching, to grow again more and more elliptical? The inference from this last view of the case would be, that the Chelonioidæ only reach in their highest perfection, namely, in the adult state, (Thalassochelys Caouana,) the form which the Amydæ exhibit when hatching. This view is at least sustained by the facts which lie before us; but further comparisons, particularly of young Sphargididæ, must show whether this is the law. But, before considering more fully the evidence thus far collected upon this point, let us examine more minutely the peculiarities which our young Thalassochelys Caouana exhibits, at the time it is hatched.

As in the Amydæ, the head of the Th. Caouana, when hatching, is exceedingly large. The horn by which the eggshell is broken is a solid excrescence of the

[1] Proc. Acad. Nat. Sc. Phila., vol. 5, p. 329, vol. 8, p. 303. [2] See above, Chap. 1, Sect. 4, p. 290 to 295.

upper jaw. On the top of the head there is a globular elevation, which does not rest merely in the skin; the height of the hemispheres of the brain themselves causes the brain-box to rise in this region. The upper jaw shows thus far no sign of the hook, which is so largely developed in the adult; on the contrary, its lower edge is notched in front. The inner margin of the sheath of this bill runs far backward over the palate, even more so than in the adult, filling up the whole triangle between the alveolar edges. The lower bill, however, is provided with a sharp hook, running upwards. The nostrils lie and open more upwards than in the adult, in which they are directed half forwards. The lower, or rather posterior eyelid, is provided with a comb-like row of scales, which fades entirely away in the adult. The neck is very bulky, and has the same transverse diameter as the head. The shape of the back is oval; there is a median excavation in front for the neck, and two lateral ones for the arms. Behind, the carapace tapers backwards, and runs out into a sharp angle. Three rows of tubercles are situated along the back, converging towards the hind end, one of them upon the median, the two others upon the costal plates. (See Pl. 6, fig. 15 and 16.) These tubercles begin in the anterior margin of each plate, and rise more and more in a longitudinal direction backwards. Four similar rows of tubercles are seen below, upon the sternal plates, and upon the plates of the bridge. (Pl. 6, fig. 14.) All these tubercular ridges arise from the thickening of the corium, and are not, as one might suppose, merely owing to a bulging of the epidermal plates. They all vanish also, sooner or later, in the adult, except those in the median line of the back, and two upon the two median rows of plates of the sternum. These ridges of tubercles, the conical shape of the whole trunk, which is far higher than in the adult and tapers backwards nearly to a point, the rounding and curving of the circumference of the body, instead of exhibiting a sharp and flattened margin as we find it in the adult, give to this young Th. Caouana a general resemblance to Sphargis which is very striking. This is particularly obvious in a cross-section through the trunk. (See Pl. 6, fig. 17.) This shows, again, that the Sphargididæ have the lowest standing among the sea Turtles, as this family preserves, in its adult form, features which prevail in the Chelonioidæ only during their earlier development.

The dorsal plates of the Th. Caouana when hatching show, however, the same great breadth in relation to the length, that we find in the hatching Amydæ; but, while in the latter all the plates increase afterwards in length at the expense of their transverse diameter, in the Chelonioidæ the median ones only grow longer than broad, while the costal ones grow broader and broader. The marginal plates vary in number. We find fourteen in a half grown specimen; while in a series of young ones their number differs from twelve to fourteen; and again they are of very unequal sizes. The plates of the sternum grow broader as the animal grows older, just the opposite of what we see in the Amydæ. This is, however, much more extensively the case with the two median rows than with the lateral rows of the bridge, which latter are nearly as broad in the hatching Caouana as the median ones; while in the adult, their transverse diameter is hardly more than one third of that of the median ones. The connection of this change of the form of the plates with the change of the whole shape of the trunk, as described in this section for the Chelonioidæ, and above (p. 294) for the Emydoidæ, is self-evident. The sculpture of the plates is exceedingly fine in the hatching Th. Caouana. This sculpture is preserved in some land Turtles and some Emydoidæ throughout life, but soon fades away in the sea Turtles. As this sculpture of the plates rests merely in the epidermal plates, it is not to be confounded with the wart-like excrescences which we meet with in the hatching Chelydroidæ and Cinosternoidæ. The latter consist in real thickenings of the corium, which ossify on a very large scale in Gypochelys, and are homologous to the rows of tubercles in Caouana which have been described above.

The tail of the young sea Turtles is exceedingly short; not any longer, in proportion to their size, than in the adult. This, again, is different from what we see in hatching Amydæ, where the tail of the young is so remarkably long; in the Emydoidæ, nearly as long as the whole carapace. If we attempt to give an explanation for this strange discrepancy, we are led to the conclusion that it must be owing to the circumstance, that, as in young Emydoidæ all the four feet serve as paddles and the tail acts as a rudder, while in sea Turtles the front feet only are paddles and the hind feet serve as rudder, the Chelonioidæ do not need such a strong rudder tail as the young Emydoidæ, which have no rudder but the tail, their hind feet being paddles. In relation to this use of the hind feet as rudders in sea Turtles, we refer to Pl. 6, fig. 13, 15, and 16, which show the green Turtle in a swimming attitude. The hind feet of Thalassochelys Caouana, when hatching, are very broad, and the front feet also are broader and much longer in comparison than in the adult. The claws of the thumb and the first finger are long and strong, while in the adult they fade nearly entirely away.

Having thus described the young Thalassochelys Caouana as the most accessible representative of the family of Chelonioidæ at the time of hatching, and compared it with the adult as we have before described the changes which the Amydæ undergo from the time of their birth to adult age, exemplifying these metamorphoses in our common Chrysemys picta, we may now proceed to compare the earlier changes which Turtles undergo in the egg, with a view of ascertaining how the differences exhibited by the two sub-orders of Testudinata are to be understood.

There is an early period in the development of the Testudinata,[1] when the embryo presents the most striking resemblance to that of any other allantoidian Vertebrate. At that age the embryo has not the remotest resemblance to a Turtle. It is then slender, and comparatively much longer than wide. (Pl. 6, fig. 28–32; Pl. 13, fig. 2–9; Pl. 14, fig. 2a, and 3–9; Pl. 16, fig. 6; and Pl. 18a, fig. 2 and 14.) There is no sign of the characteristic shield; the whole body is as elongated as that of a young snake of a corresponding age;[2] the head is very large in comparison with the size of the animal; the eyes, especially, are large and prominent (Pl. 14, fig. 3); the trunk is broader forward, and tapers gradually backward to a long tail; the limbs, when first formed, project only as small rounded paddles. (Pl. 6, fig. 28–32.)

When the shield makes its first appearance, it is only a fold in the skin, extending on both sides of the main axis, and converging in front of the body and over the tail. (See Pl. 15, fig. 13; and Pl. 6, fig. 26 and 27.) The body being still very long, the outline of this fold, when seen from above, has an ovate form. The tail of the Caouana, so short afterwards, is still as long as in the Amydæ, and its feet not longer than those of the Amydæ. (See Pl. 6, fig. 24–27.) At this age all Turtles resemble one another. I have seen Chelonioidæ, Chelydroidæ, Trionychidæ, Cinosternoidæ, and a number of species of Emydoidæ in this condition of development, which could not be distinguished one from the other.

Gradually the sides widen, so that the preponderance of the longitudinal over the transverse diameter is considerably lessened, and the characteristic features of the Turtles are brought out distinctly. (See Pl. 6, fig. 10–12, fig. 22–25; Pl. 9c, fig. 9–12, 18, 19, and 22, 23; Pl. 14, fig. 1; Pl. 15, fig. 4–6; Pl. 16, fig. 5; and Pl. 18a, fig. 2. See also Rathke, Entw. der Schildkröten, Pl. 10, fig. 8 and 9.) At this stage of the development the young of all the Testudinata have still the same form, to whatever family they may belong; but, as far as a dorsal shield is characteristic of Turtles, they are unmistakable Turtles. That no family difference can as yet be perceived is plain from the fact, that the figures here referred to represent the young of Chelonioidæ, of Chelydroidæ, of Cinosternoidæ, and of Emydoidæ.[3] The most remarkable features of this age consist not only in the perfect identity of the form, of the limbs, and of the shield, but also in the greater width of the anterior part of the shield, and in the great preponderance of the head.

But now great changes take place. Henceforth the young of different fami-

[1] The earliest stages of development are described in Part III. with fuller comparisons with the other allantoidian Vertebrates.

[2] Compare Rathke, Entwickelungsgesch. d. Natter, Pl. 1. fig. 3 and 4, with my fig. 4. Pl. 14.

[3] Pl. 6, fig. 22–25, represent the embryo of Thalassochelys Caouana; Pl. 6, fig. 10–12, that of Ozotheca odorata; Pl. 9c, fig. 9–12, that of Chelydra serpentina; and Pl. 9c, fig. 18, 19, and 22, 23, that of Chrysemys picta.

lies present marked differences. The Chelonioidæ become Chelonioid; the Chelydroidæ, Chelydroid; the Cinosternoidæ, Cinosternoid: the Emydoidæ, however, assume specific characters before they take on their Emydoid form. Though the Chelonioidæ do not widen as much in proportion to their length as the representatives of other families, the increase in width, as far as it extends in them, takes place chiefly in the anterior part of the shield, so that their form becomes more heart-shaped (Pl. 6, fig. 18–21); or, what is the same, leans already towards the form of the adult.[1] The presence of large epidermal scales upon the shield shows already, at this early age, that this young sea Turtle must belong to the family of Chelonioidæ, and not to that of Sphargididæ. In Cinosternoidæ, Chelydroidæ, and Emydoidæ the shield widens more in the posterior part; especially in Cinosternoidæ, which remain narrow (Pl. 9c, fig. 8) for a longer time than either Chelydroidæ and Emydoidæ,—or, what is the same, the Cinosternoidæ assume earlier than either the Chelydroidæ or Emydoidæ a tendency towards their permanent form. The Cinosternoidæ and the Chelydroidæ are, moreover, impressed with other characters peculiar to their family at an earlier period than the Emydoidæ. Thus the peculiar sculpture of their surface, like the keels of the Chelonioidæ, are seen very early. (See Pl. 9c, fig. 13–17; Pl. 15, fig. 7; and Pl. 6, fig. 18–20.) The Emydoidæ, on the contrary, go on widening, (Pl. 9c, fig. 20, 21, and Pl. 16, fig. 2,) and acquire a perfectly circular form, identical with that of the Trionychidæ at the time of hatching, (Pl. 6, fig. 1–7,) before their most prominent family characters begin to appear. This shows plainly that the circular form is only a transient form with the Emydoidæ, while it marks the closing development of the form of Trionychidæ, and is not even reached by the Chelonioidæ and Cinosternoidæ. In Chelydroidæ, on the contrary, the circular form is already accompanied by all the prominent family characters, (Pl. 15, fig. 1–3,) as in Trionychidæ, long before they are hatched.[2]

[1] The legs also elongate early into a form approximating that of paddles. Pl. 6, fig. 20.

[2] In Part I., Chap. 2, Sect. 8, p. 172 to 176, I have already discussed the subject of the successive development of the characters in a general way. The particular results obtained from the study of the Turtles deserve, however, a special notice. We have seen that, at a very early period, the embryo of Turtles presents all the characteristics of a vertebrated animal. But, even before it can be recognized as a Vertebrate, the germ has already acquired the independence of a new being. It is an individual, free from its parent, before it even shows to what branch of the animal kingdom it belongs. This exemplifies strikingly the importance of individuality as the most prominent feature in every organic development. But individuality is not only characteristic as the primary step in the growth of every living being; it remains also characteristic through life, so much so indeed, that individual peculiarities are superadded even to the highest features of their race, in almost every individual, to whatever species he may belong. Thus Nature herself teaches us the true value and dignity of individuality. This shows plainly how contrary to the law of organic growth must be every restraint, whether natural or artificial, which does not foster the highest development of the species. (Under natural restraint, I would consider the influence of physical

These facts show plainly, that there is a common plan of development in all Testudinata, however much they may differ in their full-grown state, and that

agents as far as they limit the growth of animals and plants; under artificial restraint, that imposed by man.) The next step in the development unfolds the prominent features of the branch of the animal kingdom to which the new being belongs. It marks the sphere in which it is to grow up. At this stage the plan of the development characteristic of the branch is, as it were, laid out, and its direction and tendency are defined; but the manner in which this is to be accomplished remains to be seen in the further progress. What unexpected resemblance to the moral and intellectual development of Man!

We might next expect that the mode of execution which characterizes classes should necessarily follow, but this is not so. Just as in other developments, the true character of the structure is frequently not apparent before it is completed: certain complications, which are embodied in it, become visible before their relation to the whole can be perceived; the form of the structure may also be recognizable before its constitutive elements can be analyzed; many details in the structure, the relative proportions of the parts to one another and their relations to the surrounding circumstances, may be fully or partially worked out long before the distinguishing character of the structure, as a whole, is appreciable.

This, also, is precisely the case with the development of different animals. In Turtles, which as Reptiles are cold-blooded, air-breathing, oviparous animals, none of the most prominent characters of the class are developed before they are hatched, (as, for instance, their aerial mode of breathing;) while some of these class characters are only recognizable in a much later period of life, (their oviparity, for instance.) Yet, as showing the manner in which the plan of structure of their branch is carried out, these characters are truly class characters. On the contrary, the special complication of that structure which characterizes the order as an order, — the separation of the body into distinct regions, a head, a neck, and a tail, and the presence of the shield and the four legs, which appear very early, even before the animal has assumed its form, — shows plainly, that in Testudinata the development of the ordinal characters precedes not only that of the characters of the family, but also that of the characters of the class. Strange as it may appear, it is unquestionable that in Turtles the ordinal characters are developed before those which characterize the class. The early separation of the head from the neck; the distinctness with which the limits between the neck and trunk, and between this and the tail, may be recognized, almost as soon as the main axis is formed; and, finally, the early development of the shield and of the four legs leaves not the remotest doubt upon this point.

Next, the form is developed, so that the most prominent family character appears immediately after the ordinal characters, in all the families of Testudinata, with the exception of the Emydoidæ, and probably also of the Testudinina, though these have not yet been observed. It is particularly interesting, that this character is fully marked in the Chelonioidæ, Trionychidæ, Chelydroidæ, and Cinosternoidæ long before they are hatched; whilst in the Emydoidæ it is not apparent for a long time, even for years after their birth, at a time when they exhibit already most of their generic and specific characters. As to the successive appearance of the generic and specific characters, even limiting the inquiry to the different genera and species inhabiting North America, much more extensive investigations, than I have been able to make thus far, are still required, before it can be satisfactorily illustrated. Meanwhile I refer to my remarks, p. 290-295. The great difficulty in these investigations consists in a correct appreciation of those peculiarities which may be *embryonic* and not *specific*, though preserved through life, and enumerated by herpetologists among the specific characters. I can state, however, that I do not know a Turtle which does not exhibit marked specific peculiarities long before its generic characters are fully developed.

It is only necessary to compare the mode of development of some of the Articulata with that of the Testudinata, to perceive at once how different the sucthe representatives of different families resemble one another more in proportion as they are younger. But the peculiarities which distinguish them most prominently do not make their appearance at the same time. Features which belong to a later stage of growth in one family become distinct in other families at a much earlier period of life.[1] Some stop at one point, while others undergo further changes. Yet, the order in which these changes take place is so uniform, that it may furnish the means of determining the relative standing of these animals, as soon as it is admitted that the characters which distinguish the earliest stages of growth are inferior to those of the mature development.

The great size of the head and neck is a remarkable feature in all the young Testudinata, in no one of which are these parts retractile. The proportions are greatly changed afterwards, and the head and neck become retractile in the Amydæ. I take it, therefore, that large-headed Turtles, the head of which cannot

cessive appearance of the characters peculiar to groups of a different importance may be in different branches of the animal kingdom. In Insects, for instance, the class characters, — the tracheæ and articulated legs,—appear always before the ordinal characters, the wings; the family characters, — the form, — are also fully defined before the ordinal characters appear, etc. How different from what we have seen in the Testudinata!

[1] A glance at Pl. 1 to 6 will show to what extent the young representatives of some families differ in form from the adult, and how early others acquire their family characters. All the figures of these plates represent young Turtles in their natural size at the time of hatching, or as nearly at that time as I could obtain them. Yet neither the CHELONIOIDÆ, (*Thalassochelys Caouana*, Pl. 6, fig. 13–16,) nor the TRIONYCHIDÆ, (*Aspidonectes spinifer*, Pl. 6, fig. 1 and 2; *Aspidonectes Emoryi*, Pl. 6, fig. 4 and 5; *Platypeltis ferox*, Pl. 6, fig. 3; *Amyda mutica*, Pl. 6, fig. 6 and 7,) nor the CHELYDROIDÆ, (*Chelydra serpentina*, Pl. 4, fig. 13–16, and Pl. 5, fig. 18 and 19; *Gypochelys Temminckii*, Pl. 5, fig. 23–27,) nor the CINOSTERNOIDÆ, (*Ozotheca odorata*, Pl. 4, fig. 1–6; *Ozotheca tristycha*, Pl. 5, fig. 20–22; *Cinosternum pennsylvanicum*, Pl. 4, fig. 7–12, and Pl. 5, fig. 16 and 17; *Cinosternum flavescens*, Pl. 5, fig. 12–15; *Cinosternum sonoriense*, Pl. 5, fig. 8–11,) exhibit marked differences in their form from the adults; or, what amounts to the same, their family characters are fully developed, not only at the time of hatching, but even long before. The EMYDOIDÆ, on the contrary, — (such as *Ptychemys concinna*, Pl. 1, fig. 13, Pl. 2, fig. 4–6; *Ptychemys mobiliensis*, Pl. 3, fig. 14–16; *Ptychemys rugosa*, Pl. 26, fig. 1–3; *Trachemys elegans*, Pl. 3, fig. 9–11; *Trachemys scabra*, Pl. 2, fig. 13–15; *Graptemys geographica*, Pl. 2, fig. 7–9; *Graptemys LeSueurii*, Pl. 2, fig. 10–12, and Pl. 5, fig. 5–7; *Malacoclemmys palustris*, Pl. 1, fig. 10–12; *Chrysemys picta*, Pl. 1, fig. 1–5, and Pl. 3, fig. 4; *Chrysemys marginata*, Pl. 1, fig. 6, and Pl. 5, fig. 1–4; *Chrysemys oregonensis*, Pl. 3, fig. 1–3; and *Chrysemys Bellii*, Pl. 6, fig. 8 and 9; *Deirochelys reticulata*, Pl. 1, fig. 14–16, and Pl. 2, fig. 1–3; *Emys Meleagris*, Pl. 4, fig. 20–22; *Nanemys guttata*, Pl. 1, fig. 7–9; *Actinemys marmorata*, Pl. 3, fig. 5–8; *Cistudo virginea*, Pl. 4, fig. 17–19; and *Cistudo ornata*, Pl. 3, fig. 12 and 13,) — have almost perfectly circular outlines, and exhibit in no way the slightest tendency to the more or less elongated form of the adult, with the exception perhaps of Malacoclemmys palustris, and Deirochelys reticulata, which are slightly oval; so that, at the time of hatching, no Emydoid has assumed the form characteristic of that family. *Xerobates Berlandieri*, Pl. 5, fig. 17–19, the only young representative of the family of Testudinina which I had an opportunity of examining, shows that these Turtles also are orbicular before they assume their final, characteristic form.

be drawn in at all, or only partially, are inferior to the others, or exhibit what may be called *embryonic* characters.[1] This is the case in the Chelonii, which have always been considered as the lowest Testudinata, and, among Amydæ, to some extent in the Chelydroidæ, which stand very low in their sub-order. In all younger embryos the limbs are paddles; they remain paddles in the Chelonii, whilst they are terminated by feet, with more or less distinct fingers, in the Amydæ. We thus have here an additional evidence that the Chelonii are inferior to the Amydæ. There is, however, a remarkable feature in the development of the limbs in Chelonii: the paddles of the young sea Turtle, though identical with those of the Amydæ, differ from what they are in the adult age, and yet they remain paddles. They exhibit, as it were, overgrown embryonic features, such as characterize the types which I have called *hypembryonic*.[2]

The shield presents similar transformations. At first oblong, and narrower behind than in front, it grows gradually broader, assuming even a circular form. But the characters of the adult are already impressed upon the shield of the Chelonii before it grows very wide; so it is also with the Cinosternoidæ and Chelydroidæ, while in Trionychidæ the flat, roundish form in its fullest expansion is that which the adult preserves. The Emydoidæ have also reached that circular form at the time of hatching, but they afterwards grow again more elongated. The question thus arises, Is there a retrograde development in the Emydoidæ, or not? For my part, I am satisfied that it is not the case. Considering the difference of the elongated form of the Emydoidæ, in which the hind end is generally the broadest, whilst in the elongated shield of the embryo this is the reverse, and considering further the closer relation of the Emydoidæ and Testudinina, in which latter the two ends of the body balance one another so evenly, I believe that the elongation of the Emydoidæ, subsequent to their circular outline, marks a real progress. I consider, therefore, the later widening of the Chelonii, as observed in the adult, as a progressive development, which is attained only late in life in that family; so that it might be said, that, in this respect, the Chelonii do not even reach in old age the form to which the Trionychidæ and Emydoidæ attain at the time of hatching, and at which the Trionychidæ stop, whilst the Emydoidæ take another start in a higher direction, to approximate the form prevailing in the adult Testudinina. A knowledge of the early embryonic changes of the Testudinina is still wanting to carry out fully these comparisons.

I am inclined to consider, further, the presence of keels along the back as characters of inferiority, considering the prominence of these keels in the lowest Chelonii, the Sphargididæ, and their presence in young Chelonioidæ, which lose

[1] Comp. Part I., Ch. 1, Sect. 25, p. 112 to 116.

[2] See Part I., Ch. 1, Sect. 25, p. 116.

them more or less completely in old age. Carinated species also are more numerous among the lower Amydæ than among Testudinina; all the Chelydroidæ and Cinosternoidæ are more or less carinated, especially in their younger age, and they are inferior to the Emydoidæ; many of the most aquatic Emydoidæ are also carinated, some through life, others only in the younger age; and we have already seen that the aquatic species are inferior to the terrestrial ones, and that the young Emydoidæ are more aquatic than the adults.[1]

From the few facts which I have already collected,[2] I am convinced that much valuable information could be obtained from a similar comparison of the changes which our common Mammalia and Birds undergo in early life, and that the time is not far distant when, in this way, the relative standing of the representatives of every family will be determined with remarkable precision. The results to which I have arrived by the study of the young Turtles will, I hope, stimulate other naturalists to turn their attention also to this interesting subject. Happily the time is coming when fewer new species are to be found, and, from want of materials for their ordinary work of registering animals, with scanty or insufficient characteristics, zoölogists may be led to more important investigations.

SECTION V.

GENERA OF TRIONYCHIDÆ.

It appears from the statement of Duméril and Bibron,[3] that Schweigger was the first to perceive the necessity of separating the soft-shelled Turtles as a distinct genus, which he called AMYDA, in a paper presented by him to the Academy of Sciences in Paris, in 1809. Geoffroy, however, changed that name to TRIONYX,[4] which Schweigger himself adopted when he published his paper,[5] as also did all herpetologists afterwards. This genus was not further subdivided until Wagler showed, in 1830, that it embraced species which exhibit marked structural differences, in the connection of the plastron and hind legs, and in the ossification of the marginal rim. For those species which have bony plates along the margin, and a wide hind lobe of the plastron, he retained the name of Trionyx,

[1] Compare the note to p. 293.

[2] See AGASSIZ, (L.,) Lake Superior. Boston, 1850, p. 191; also Twelve Lectures on Comparative Embryology, p. 8 and 101.

[3] Erpét. génér. vol. 2, p. 464.

[4] Ann. du Mus. de Paris, vol. 14, 1809.

[5] Prodromus Monographiæ Cheloniorum; Königsberg. Archiv, 1812.

and united all the others under the name of Aspidonectes, supposing that the soft marginal dilation of the shield assists in swimming, which is only true in as far as it forms a sharp cut-water, for it is not moved up and down, as are the wings of the Skates.

The two genera proposed by Wagler have since been adopted by all modern herpetologists, who have vied with one another in changing their names, although not to the real advantage of science. Thus Duméril and Bibron, discarding entirely the old generic names, call Gymnopus the genus which Wagler had named Aspidonectes, and Cryptopus, that for which he had retained the name Trionyx.[1] J. E. Gray, on the contrary, restored the name Trionyx to the genus which Wagler had called Aspidonectes,[2] and gave a new name, Emyda, to Wagler's Trionyx. In 1836, Fitzinger[3] introduced further generic distinctions in this family, calling Trionyx the same genus for which Wagler had retained that name; Aspidonectes, the Trionyx javanicus and ægyptiacus of Geoffr. and the Trionyx indicus of Gray, and proposing three new genera, one under the name of Platypeltis for the Tr. ferox, *Schw.*, and spinifer and ocellatus, *LeS.*; another under the name of Pelodiscus for the Tr. sinensis, *Wieg.*, and the Tr. labiatus, *Bell*; and a third one, for which Fitzinger revives the old name Amyda for the Tr. subplanus, *Geoffr.*, and the Tr. muticus, *LeS.*[4] But all these new genera are founded upon delusive characters, as Gray has already stated, which depend only upon the progress of the ossification of the shield, and may be observed in specimens of different ages of one and the same species, as my numerous skeletons of these Turtles clearly show. Moreover the difference in the length of the tail is only sexual; the tail

[1] Erpét. génér. vol. 2, p. 472 and 475, on the ground that Aspidonectes and Trionyx have both three nails to their feet. With such principles half the names introduced in Zoölogy or Botany might be changed. The new names proposed by Duméril and Bibron for Trionyx and Aspidonectes may themselves serve as an example. Now that it has become necessary to subdivide into distinct genera the species which Duméril and Bibron refer to Gymnopus, that name would be inappropriate, according to their own views, since all these new genera have equally naked feet; and the genus Cycloderma of Peters would render a change for Cryptopus necessary, as it has retractile feet, like Cryptopus.

[2] It may be said that Wagler ought to have retained the name Trionyx for the species longest known; but he undoubtedly had the right to name as he pleased the genera he first recognized; and as he chose to apply that of Trionyx to the species which have the marginal bony plates and a broad hind lobe of the plastron, later writers have only introduced confusion in the nomenclature of this family by reversing his arrangement, which, according to the law of priority, must in the end be adopted, in spite of every objection. The name Emyda, which is also synonymous with Cryptopus, Dum. and Bibr., appears for the first time in Gray's Syn. Rept., appended to Griffith's Transl. of Cuvier's Règn. Anim., 1831.

[3] Systematischer Entwurf einer Anordnung der Schildkröten, in Annalen des Wiener Museums, 1836, 4to.

[4] To these genera Fitzinger adds Potamochelys for Tr. javanicus, in his Systema Reptilium, published in 1843.

being very short in the females, and extending beyond the rim of the shield in the males of all the species I know. In the Catalogue of the British Museum, J. E. Gray restricts, in 1844, the name of Trionyx to the North American species; separates Trionyx indicus, *Gray*, as a distinct genus under the name of Chitra; changes Fitzinger's Amyda to Dogania, excluding however from it Tr. muticus, which the Austrian herpetologist associated in that genus with Tr. subplanus; and calls Tyrse a genus embracing Tr. gangeticus, *Cuv.*, javanicus, *Geoffr.*, ægyptiacus, *Geoffr.*, and a few other less known species; and, finally, retains the name Emyda for Wagler's Trionyx. To these, Dr. W. Peters[1] has added a new genus from Mozambique, in which the absence of bony plates in the marginal rim is combined with a broad hind lobe of the plastron, and which he calls Cycloderma. Thus we have not less than thirteen generic names for about the same number of species, some of which are still very imperfectly known.

Under these circumstances a critical revision of the genera of Trionychidæ appears as a great desideratum in herpetology. But the materials for such a task seem to exist nowhere, if I judge from the published catalogues of the great museums in Europe; and I possess myself large numbers of specimens only of the North American species. Yet, from their careful examination I have gathered data which may be of service to a future monographer of this type. Thus I have already satisfied myself that the number of our species is much greater than is generally supposed;[2] and a careful study of their skeleton has taught me what constitutes generic characters in this family, so that I feel prepared to express an opinion respecting the value of the genera proposed by other writers.[3] I hold that the genus TRIONYX, as limited by Wagler, is natural; it embraces the species described by Gray under the name of Emyda, and by Duméril and Bibron under that of Cryptopus. Next to it stands CYCLODERMA, *Peters*, also a natural genus. The Indian genus CHITRA, *Gray*, is no doubt well founded, and so also, probably, is DOGANIA, *Gray*, for which the name Amyda, *Fitz.*, might have been adopted by Gray, as this is older. But here ends the list of genera thus far proposed which are at all circumscribed within natural limits, as I can show that Aspidonectes, *Wagl.*, Gymnopus, *Dum.* and *Bibr.*, Platypeltis, *Fitz.*, Pelodiscus, *Fitz.*, Potamochelys, *Fitz.*, Trionyx, *Gray*, and Tyrse, *Gray*, either contain species which do not belong

[1] Monatl. Bericht der Akad. d. Wiss. in Berlin, 1855, p. 216.

[2] Dr. Holbrook reduces the North American Trionyx to two species, and so do Duméril and Bibron, and J. E. Gray. It will be seen hereafter, that the supposition of LeSueur respecting the species occurring in the North-western States of the American Union, which he considered as distinct from the southern species, was correct.

[3] In this connection I would remark, that it is hardly possible to distinguish the Trionychidæ by their external characters, and that nothing short of a careful examination of the jaws, and especially of the skull, will reveal their generic differences.

to the same genus, or ought also to embrace other species, which are referred to different genera. Of Aspidonectes, *Wagl.*, Gymnopus, *Dum.* and *Bibr.*, and Trionyx, *Gray*, this will be self-evident, as soon as it is shown that the North American species, which have all been referred to these genera, belong in reality to three different genera. Pelodiscus and Potamochelys, *Fitz.*, and Tyrse, *Gray*, run together in the same manner, on account of the heterogeneous species they contain. Therefore, one question only remains, Which of these names are to be retained for the North American species? Of all the generic names not yet strictly applied, Aspidonectes, *Wagl.*, is the oldest; and as it was established for species, some of which, as Tr. javanicus and ægyptiacus, agree with some of the American ones, as Tr. spinifer, *LeS.*, I shall retain that name for the genus to which our Tr. spinifer belongs. Next stands the genus Platypeltis, *Fitz.*, which, though made to include also Tr. spinifer, *LeS.*, is yet meant for Tr. ferox, *Schw.*, and may therefore be retained for the genus of which Tr. ferox *Schw.* must be considered as the type, and which must also embrace Tr. gangeticus, *Cuv.* The adoption of these two genera renders Gray's name Tyrse and Fitzinger's Potamochelys and Pelodiscus entirely superfluous, as Tyrse includes Tr. javanicus, ægyptiacus, and gangeticus, and Potamochelys *Fitz.* is founded upon Tr. javanicus, while Pelodiscus rests upon Tr. sinensis, *Wiegm.*, and labiatus, *Bell.* We have thus appropriated, for six natural genera, six of the names introduced among the Trionychidæ, and shown that six out of the remaining seven have no scientific value. But there is a third American genus, founded upon Tr. muticus, *LeS.* I am glad to have an opportunity of honoring the memory of Schweigger by fixing upon this genus the name of Amyda, first proposed by Schweigger for the whole type of Trionychidæ, though wantonly rejected by Geoffroy, and so vaguely applied by Fitzinger to one of his genera.

It has already been stated that the eggs of the Trionychidæ (Pl. 7, fig. 20–23) are spherical and very brittle.[1] The young at the time of hatching (Pl. 6, fig. 1–7) exhibit fully their family character; they are flat, discoid, and orbicular in outline; their head only is comparatively shorter and rounder than in the adult, and the neck thicker, but the proboscis is very prominent; the feet have already their characteristic web, and the membranous fold which extends along the upper edge of the four legs (Pl. 6, fig. 2 and 5). The ossification of the shield is so little advanced that there is no sign of a carapace or plastron visible externally through the soft, scaleless skin.

The Trionychidæ were for some time supposed to have existed upon our globe as early as during the Devonian period. I have shown, however, that the

[1] See Part II., Chap. 2, Sect. 4, p. 334.

fossil remains of Caithness referred to this family are those of an extinct family of Fishes.[1] The oldest deposits in which true Trionychidæ have been observed are the green sands of New Jersey, according to Dr. Leidy.[2] Professor Owen describes and illustrates very fully a number of tertiary species, which are the oldest he has seen.[3]

I. AMYDA, *Schw.* (Ag.)

The head is long, low, narrow and pointed in front, and the angle of the front part with the brain-box comparatively small. The nasal region is compressed sidewise, and drawn out long and narrow. The nostrils are cut in a peculiar way, and are not subdivided on each side by an internal ridge, as is the case in Aspidonectes and Platypeltis (Pl. 6, fig. 2a, 3a, 4a, and 7); they lie rather under than at the tip of the proboscis, are widely apart, broader below, and converge and taper upwards. The outer surface of the maxillaries curve inward under the eyes and nose, so that the mouth is small and the nasal region rounded. On account of the compression spoken of above, the sides of the mouth are concave outward from the hind to the front end, and that part of it which is under the nose is narrow and long. The alveolar edge of the upper jaw is turned down farthest at the front end, and less and less backward, fading out before reaching the hind end of the maxillaries; it is sharp in front, and toothed near the hind end; but the teeth, though quite prominent in the bill, are hardly perceptible in the jaw itself. The horizontal alveolar surface is narrow; it is widest near the hind end, curves down under the eye, and up again under the nose. There is in this genus a large opening in the skull between the maxillaries and the vomer. The lower jaw is also compressed sidewise and drawn out long and narrow under the nose, and its sides are concave outward. Its lower edges meet from the two sides where the compression begins, and the narrowed part lies at the sides of the symphysis, and the latter is carried far forward in rising from the lower to the upper edge of the jaw. The long, narrow alveolar surface thus formed at the symphysis descends inward from the outer edge, slightly at the front end, more and more backward, and from the symphysis to the angle of the jaw that surface is very narrow and almost vertical. The alveolar edges are sharp all round. Thus we have in this genus a small

[1] See Part II., Chap. 1, Sect. 17, p. 303.

[2] Proc. Ac. Nat. Sc. Phil. vol. 5, 1851, p. 329, and vol. 8, 1856, p. 73.

[3] R. Owen and T. Bell, Fossil Reptilia of the London Clay, in Trans. of the Palæont. Society, London, 1849, p. 46.

mouth with a sharp bill, and with two long surfaces under the nose, which are brought close together when the mouth is shut. The food found in the stomach of a specimen of Amyda mutica, examined in a fresh state, consisted of larvæ of Nevropterous insects.

The type of the genus Amyda is LeSueur's Trionyx muticus. It is thus far the only species known to belong to this genus, unless Trionyx euphraticus, *Geoffr.*, be generically identical with it, which I have no means of ascertaining.

AMYDA MUTICA, *Fitz.* The description of this species by LeSueur is the fullest and most accurate.[1] He has distinctly pointed out its most prominent specific peculiarities: the depression along the middle line of the back, instead of an obtuse keel, the total absence of spines along the anterior margin of the carapace and of tubercles upon the back, and the peculiar coloration of the lower surface, which is whitish, without spots or mottled marks, as occur under the neck and upon the lower surface of the feet of Tr. spinifer, with which it has often been confounded. LeSueur also mentions the long, narrow, and pointed jaws, which constitute one of its generic peculiarities. The form of the nostrils, first noticed by Dr. Holbrook, is also generic.

I have seen more than twenty specimens of both sexes, in every stage of growth. The males have always a longer tail than the females, extending beyond the margin of the disc, while it is concealed under it, in the other sex. The young, (Pl. 6, fig. 6 and 7,) at the time of hatching, and for some time afterwards, are entirely white below, even under the neck and upon the lower surface of the feet; the latter, however, becomes bluish gray with age, but it is never spotted or mottled. Upon the sides of the head, from the eyes backwards, runs a narrow white band bordered by black lines, which is merged behind in the white surface of the lower side of the neck, but extends forwards across the eye to the tip of the proboscis. This band disappears more or less in old specimens. In very young specimens, the back has slight black spots upon an olive colored ground, and exhibits, along the hind margin and the sides of the carapace, a broad yellowish band circumscribed by a black line. With advancing age the marginal band disappears, and the dark marks upon the back spread until they vanish entirely, and the ground becomes itself darker and more gray-

[1] In Mém. Mus. Hist. Nat. Paris, 1827, vol. 15, p. 263, Pl. 7. It has since been described by Major LeConte, (Lyc. Nat. Hist. New York, vol. 3, p. 95,) and by Dr. Holbrook, (N. Amer. Herp. vol. 2, p. 19, Pl. 2.) J. E. Gray considers it and Tr. ferox as being the only genuine representatives of the genus Trionyx, as he would limit it. DeKay (Zool. of New York, vol. 3, p. 7, Pl. 6, fig. 11) represents it as the young of Tr. ferox, though he considered it at first as a distinct species, for which he had proposed the name of Tr. ocellatus. His figure leaves no doubt that he had a specimen of Tr. muticus before him. Wagler refers it to his genus Aspidonectes, and Duméril and Bibron to their genus Gymnopus.

ish brown. The largest specimen I have seen measured twelve inches from the front to the hind margin of the carapace, and ten inches across.

This species, which is the smallest of the North American Trionychidæ, extends from the States of New York and Pennsylvania westwardly to the tributaries of the Missouri, and the upper and middle Mississippi. I have never seen specimens from the lower course of the Mississippi, nor from the Southern and South-eastern States. It is common in Lakes Erie and Ontario, (Maj. LeConte;) in Ohio, (Dr. Kirkland,) and in Indiana, (LeSueur.) Through the kindness of Prof. Rich. Owen I have obtained specimens from the very locality from which LeSueur described his. Dr. J. Rauch has sent me specimens from Iowa, Mr. G. Stolley from the Osage River in Missouri, and Prof. Sp. Baird from the Alleghany River in Pennsylvania. The eggs are smaller than those of the other species of this family which I know. They are represented (Pl. 7, fig. 21) from specimens sent me by Dr. J. Rauch of Burlington, Iowa, and by Mr. Franklin Hill of Delphi, Indiana.

II. PLATYPELTIS, *Fitz.*

The head is short, broad, and high; its front part is turned down steeply, and makes a sharp angle with the brain-box. The sides of this part approach each other gradually to the base of the proboscis, which is straight. The nostrils are terminal, and nearer together than in Amyda, crescent shaped in form and vertical in position; they are subdivided by a horizontal ridge, projecting on each side of the median partition, which is wider than in Aspidonectes. The outer surface of the maxillaries slants far outward from the suture with the prefrontals down to the alveolar edge, thus making the mouth very broad. The alveolar edge is blunt, except at the front end; it is turned down but little at the sides, and flares out so much there that in the adult there is but little distinction between the vertical and horizontal alveolar surfaces, and both together form one very broad surface adapted to crushing; but, at the front end, this surface is narrow and nearly vertical. There is here, as in Amyda and Aspidonectes, a large opening in the skull between the intermaxillaries and the end of the vomer. The lower jaw, like the upper, has a very broad alveolar surface, which also continues broad back to the hind end of the maxillaries, projecting near that end far over both the outer and inner surfaces of the jaw below, and reaching inward farther even than its lower edge. This surface is nearly flat at the symphysis, but it has a deep depression near the hind end. In this genus, then, the mouth is large, but short; the jaws are strong, and the alveolar surfaces broad and blunt, and well fitted to crush. The shells of a Paludina and fragments of Anodontas were found in large quantities in the stomach of a specimen of Trionyx ferox, the type of the genus, examined shortly after it had been caught. Similar fragments were found in the fæces of other specimens preserved alive.

The type of the genus Platypeltis is the Tr. ferox, *Schw.* It is the oldest species of this family known from North America. It was first described by Dr. Garden of Charleston, in a paper printed in the Philosophical Transactions of the Royal Society of London, in 1771, from which all later writers have borrowed their information, until Major LeConte, Duméril and Bibron, and Dr. Holbrook[1] gave a fuller account of this species. I have little to add to their descriptions; but these authors are certainly all mistaken in considering this species as identical with LeSueur's Tr. spinifer. Not only are Tr. ferox, *Schw.*, and Tr. spinifer, *LeS.*, distinct species, but they belong unquestionably to different genera, as a comparison of the skulls will show at first sight. I have compared large series of specimens of both kinds, from the very young to adults, and can speak with confidence upon this point. Though Fitzinger unites also Tr. spinifer and ferox as synonymes, I have thought it preferable to adopt the name he proposes for this genus, and assign to it a definite meaning, than to frame a new one, which in the end would appear co-extensive with Platypeltis.

PLATYPELTIS FEROX, *Fitz.*[2] This species is only found in the Southern States, from Georgia to Western Louisiana. Dr. W. B. Daniel has sent me many specimens from Savannah, its northernmost station in the Atlantic States. It abounds in the St. John River of Florida (Bartram, LeConte). I am indebted for many specimens from Western Georgia and Western Florida to Dr. Gessner, of Columbus, and Mr. Eppes, of Tallahassee. Dr. Nott has sent me others from Alabama, especially a series of very young ones. To Professor Chilton, of New Orleans, I am indebted for specimens from the Lower Mississippi; and to Mr. Winthrop Sargent, of Natchez, for the largest specimens I have ever seen or heard of, one of which measured eighteen inches and a half from the front to the hind margin of the carapace, and sixteen across.

[1] Compare the works q. a., p. 30, for further references, but exclude from their synonymy every thing that relates to Tr. spinifer, *LeS.*

[2] The names most frequently applied to this species, by different authors, are Testudo ferox, Trionyx ferox, Tr. carinatus, Tr. georgicus, Tr. Brongniarti, Tr. Bartrami, Tr. Harlani, Aspidonectes ferox, Asp. carinatus, and Gymnopus spiniferus. The external resemblance between Platypeltis ferox and Aspidonectes spinifer and asper, is so great, that I am not surprised that they have been confounded, or even deliberately considered as identical. We have, in fact, a case here, of which a few other examples only are thus far known, in which, under the most surprising similarity of external appearance, marked structural peculiarities, amounting to generic differences, are hidden. I have already pointed out such cases in the genera Phoxinus and Chrosomus, and in the genera Carpiodes, Bubalichthys, and Ichthyobus, among Cyprinoids (Amer. Journ. of Sci. and Arts, 2d der. vol. 19,

It is true that this species very much resembles Tr. spinifer, *LeS.*, in its external appearance; but, even without referring to their generic characters, they may readily be distinguished in every stage of growth. The male of Platypeltis ferox, with its projecting tail, is much more oblong[1] than that of Aspidonectes spinifer, while the females are very similar in their rotundity. The tubercles upon the shield are also larger and more numerous in the male ferox than in the female; just the reverse from what we see in spinifer. The young ferox (Pl. 6, fig. 3) has two or three concentric black lines separating the pale margin from the light brown colored back, which are sometimes preserved even to their full-grown size; in Asp. spinifer I have never observed more than one such line, which disappears rather early. The back of Pl. ferox is studded with well-defined black dots, which become ocellated only in later years, and are finally changed into dark blotches in the adult. The lower surface is entirely white, even the lower surface of the feet, which are mottled, streaked, and dotted with black in Aspidonectes spinifer, Asp. nuchalis, and Asp. asper. Aspidonectes spinifer never grows so large as ferox, and is only found in the Northern States, within the same limits as Amyda mutica, with which it is mostly found associated. The eggs of Platypeltis ferox (Pl. 7, fig. 22) are of a somewhat smaller size than those of Aspidonectes spinifer: they are, however, a little larger than those of Amyda mutica, represented upon the same plate.

The peculiar coloration of the lower surface of the feet, and the mottled appearance of the lower part of the neck, of Asp. spinifer, first attracted my attention as differing from Platypeltis ferox, and led me to a careful revision of our Trionychidæ. Trusting to the accuracy of previous writers, I have myself believed, for a number of years, that there existed only two species of that family in the United States, and that these two species belonged to one and the same genus, until large collections of specimens from every part of the country, and a thorough examination of their structure, satisfied me that we possess not less than six species, belonging to three different genera: one Amyda, one Platypeltis, and four Aspidonectes, the geographical distribution of which is particularly interesting. In the North-Western States, two species occur together, belonging to two different genera, Amyda mutica and Aspidonectes spinifer; in the Middle Western States one species, Aspidonectes nuchalis; in the South-Eastern

p. 71.) Many similar examples might be quoted among the Rodentia.

[1] The figure of Dr. Holbrook, in the North American Herpetology, Vol. 2, Pl. 1, represents very distinctly this oblong form of the male Platypeltis ferox. It is less so in Aspidonectes spinifer, as the figure of LeSueur published in the Mém. du Mus., Vol. 15, Pl. 6, distinctly shows. These two figures will at once exhibit the differences characteristic of the forms of the two species.

and Southern States, two species, belonging to two different genera, Platypeltis ferox and Aspidonectes asper; and in the South-West, in Texas, one species, Aspidonectes Emoryi.

III. ASPIDONECTES, *Wagl.*

The head is broader, and less flattened, than in Amyda. The sides of the front part of the head approach each other continually, and are nearly straight from behind forward. The proboscis is straight, and cut vertically; the nostrils are crescent-shaped, and subdivided by a projecting ridge arising from the middle of the narrow vertical partition which separates them. The outer surface of the maxillaries curves out, from the suture with the prefrontals, for about half its width, then turns down and descends almost vertically to the alveolar edge. Thus the mouth is broader, and the nose less rounded, than in Amyda. The alveolar edge curves down slightly from end to end; it is sharp, but in the adult it has no teeth. The vertical alveolar surface is broadest near the front end, and narrows thence backward. The horizontal alveolar surface is broadest at the hind end, and narrows thence forward; it descends nearly constantly from the hind to the front end. There is here, as in Amyda, a large opening in the skull in front of the vomer. The symphysis of the lower jaw is much shorter than in Amyda, and the end of the jaw broader. The alveolar surface narrows from the symphysis backward; at its front end it descends steeply from the outer edge inward, but at its hind end the inner edge is raised, so that there is a slight depression in the surface there. The alveolar edge is sharp all round. Thus we have in this genus stronger jaws, with broader alveolar surfaces, than in Amyda, and cutting, but not toothed, alveolar edges.

ASPIDONECTES SPINIFER, *Ag.* All modern herpetologists seem to agree in the opinion that Trionyx spinifer, *LeS.*, is identical with Tr. ferox, *Schw.* I have satisfied myself, by a direct comparison of a large number of specimens of every age, that this is a mistake. It is true, Dr. Holbrook has shown[1] that there is an easy water communication between the different stations occupied by these Turtles; but it does not follow, that, because animals may migrate without serious obstacle over any extent of land or sea, they are necessarily the same within the boundaries of such areas. The ingenious suggestion of Dr. Holbrook, intended to explain the presence of a southern species in the waters of the North-Western and North-Eastern States, as far as Lake Champlain, has in reality only put an end to all further comparisons between our Trionychidæ.

[1] North American Herpet. Vol. 2, p. 15.

The only correct description I know of Aspidonectes spinifer is that of LeSueur.[1] All later writers have confounded it more or less with Platypeltis ferox, until the two were finally considered as identical. Its chief specific characteristics are not the spines along its anterior margin, whence the name is derived, — for such spines exist more or less in all species of the genus Aspidonectes, — but the blunt keel, which extends along the median line and slopes uniformly upon the sides, a character by which it is easily distinguished from Aspidonectes nuchalis, a species thus far overlooked, in which there is a marked depression on either side of a similar keel along the median line. When young, Aspidonectes spinifer (Pl. 6, fig. 1 and 2) is dotted all over the back with small ocellated spots, which increase with age, and then fade into irregular blotches upon a darker or lighter yellowish brown ground. In early age, the margin has a narrow, light-colored seam, separated from the darker disc by a black line, which fades and disappears with age. The front part of the neck is mottled with yellow and black, and so, also, is the lower surface of the feet. Besides the difference in the length of the tail, the male differs from the female by a slightly oval form. The spines along the front margin, and the tubercles which rise behind them and upon the hind part of the carapace, are less prominent in the males than in the females, exactly the reverse from Platypeltis ferox. The largest specimen I have seen, measured fourteen inches from end to end of the carapace. The eggs, (Pl. 7, fig. 23,) for which I am indebted to Dr. Rauch and Mr. Franklin Hill, are a little larger than those of Platypeltis ferox. Major LeConte questions the propriety of the name ferox for the southern Trionyx, as he says they are not more inclined to bite than most other species of Testudinata; but LeSueur reports that he was severely bitten by Tr. spinifer, and I have myself experienced the power of its jaws. This apparent contradiction, as long as ferox and spinifer were considered as the same species, may be owing to the generic differences of these Turtles. Aspidonectes spinifer is common from Lake Champlain and the western parts of the States of New York and Pennsylvania, through Ohio, Indiana, Illinois, Missouri, Michigan, Wisconsin, and Iowa, to the head waters of the Mississippi and Missouri, even to the very foot of the Rocky Mountains (Lewis and Clark). It inhabits most of the tributaries of the Mississippi within the State of Wisconsin (Dr. P. R. Hoy). I have received specimens from Lake Champlain, through the kindness of the late Rev. Zadd. Thompson; and from the

[1] In the Mémoires du Muséum d'Histoire naturelle, Vol. 15, p. 258, Pl. 6, under the name of Trionyx spiniferus, which ought, however, to be written spinifer. LeSueur describes as a variety of this species, under the name of Trionyx ocellatus, what was, no doubt, a young female. Wagler considers this species as synonymous with Platypeltis ferox. DeKay's Trionyx ocellatus is Amyda mutica.

Alleghany River, in Western Pennsylvania, from Professor Baird. It was not known in the State of New York before the completion of the Erie Canal; but since, it has been caught in the Mohawk and in the Hudson Rivers, near Albany (DeKay). Professor Rich. Owen has sent me some from the Wabash, near New Harmony, in which place LeSueur first observed this species. It is abundant in Lakes Ontario and Erie, in the streams that flow into these lakes, (Say and LeConte,) and in all the streams of Ohio (Kirtland). I am indebted for specimens from the Ohio to Mr. Jos. Clarke, of Cincinnati; from Northern Indiana to Mr. Franklin Hill, of Delphi; from Michigan, to Dr. A. Sager and Professor Alex. Winchell, of Ann-Arbor; from Illinois, to Mr. J. H. McChesney; from Iowa, to Dr. J. Rauch; from the Osage River, in Missouri, to Mr. G. Stolley; and from Fort Union, on the Upper Missouri, to the Smithsonian Institution. It is frequently found in the smaller streams that discharge into the Missouri (Say). The occurrence of this species so far north contrasts strangely with the opinion, prevailing among herpetologists, that the representatives of this family are inhabitants of the large rivers of the tropics.[1]

ASPIDONECTES ASPER, *Ag.* I have for a long time known only an imperfect skeleton of this species, belonging to the Smithsonian Institution, and prepared from a specimen forwarded by Professor B. L. C. Wailes, of Washington, Mississippi. Afterwards I obtained, through the agency of Dr. L. Harper, a stuffed specimen belonging to the Museum of the University of Oxford,[2] that had been collected during the geological survey of Mississippi, under the superintendence of Professor Wailes. Lately I have received a number of living specimens, through the kindness of Mr. Winthrop Sargent of Natchez, which confirm the opinion I had formed, from the scanty materials at first at my command, that there exists, in the South-Western States, a distinct species of Aspidonectes, which might easily be mistaken for Asp. spinifer, and even be confounded with Platypeltis ferox.[3]

Aspidonectes asper is at once distinguished from all the other species of this

[1] Comp. Dum. and Bibr. Erpét génér. Vol. 2, p. 449, where it is stated that all the species, the origin of which is known, inhabit the rivers and lakes of the warmest parts of the globe, among which, it is true, they mention the Ohio.

[2] Upon application of Dr. Harper, the trustees of the University at Oxford very liberally consented to forward to me for examination all the specimens of Testudinata collected during the geological survey of the State of Mississippi. These specimens have been of very great importance to me in fixing the geographical range of many species, which before were not known to occur in the lower course of the Mississippi.

[3] I have no doubt that such a confusion generally prevails, as no zoölogist has thus far alluded to the presence of two representatives of this family in the Southern States, and the very specimen of the Museum of Oxford, alluded to above, bears the name of Trionyx ferox.

genus, and also from Platypeltis ferox, by the very coarse and large tubercles of the front and hind part of the carapace, which extend, behind, even over the bony shield, and are there supported by prominent warts of the bony plates. These bony warts exist in no other species with which I am acquainted: their form is very irregular, sometimes oblong and sometimes orbicular; they also project more or less. Another marked peculiarity of this species consists in the greater bluntness of the extremities of the jaws, which are more rounded than in Asp. spinifer. The jugal arch is also broader. The difference between the males and the females is more striking in this species than in any other, the males being regularly oval, whilst the females are almost circular in their outline. I have noticed no difference between the coloration of this species and that of Asp. spinifer, except that in younger specimens of Asp. asper there are, as in Platypeltis ferox, two or three black lines separating the pale rim of the posterior margin, whilst there is only one in Asp. spinifer; these lines are, however, closer together, and fade away sooner than in Platypeltis ferox. This combination of external characters, partly resembling Asp. spinifer and partly Plat. ferox, explains how these species could be mistaken as one. Indeed, were it not for their generic characters, a series of specimens might easily be selected, showing every possible transition between them. I do not know, in the whole animal kingdom, another type, in which the importance of the study of the generic characters, prior to distinguishing species, is brought more forcibly before the student, than the family of Trionychidæ, unless it be that of Cinosternoidæ.

Thus far I have had no opportunity of examining the eggs of this species; nor do I know the appearance of the young, recently hatched, unless a young specimen, sent me by Professor Baird from the north-western part of Louisiana, be the young of this species. It differs but slightly from the young Aspidonectes nuchalis; it has the same large ocelli, but the bridge connecting the carapace and plastron, and a longitudinal area, before and behind the bridge, are tinged with black.

ASPIDONECTES NUCHALIS, *Ag.* I have only seen three adult specimens of this species, for which I am indebted to Prof. Lindsley, of Nashville, Tennessee, and a number of young ones, which I owe to the kindness of Prof. Baird; the first collected in Cumberland River, the others in the head waters of the Tennessee River. I learn from Dr. Samuel Cunningham, of Jonesboro', that, in the higher tributaries of the Tennessee River, a species of Trionyx, which I suppose to be this, is found at a considerable height in the Alleghanies; a very unexpected fact, considering the prevalence of this family in warmer regions. This species differs strikingly from Asp. spinifer in the much more elongated form of the male, and in the great development of the marginal spines and of the tubercles upon the carapace, which project very slightly in the male Asp. spinifer. The young differ also in having, at birth, comparatively large ocelli upon the carapace, which fade into large blotches in the adult. But the most prominent specific character consists in the marked depressions on either side of the blunt median keel, and also in the triangular dilation of that keel behind the front margin of the carapace. The lower surface of the neck and feet is mottled and speckled, as in Asp. spinifer. From this scanty information it may be inferred that Asp. nuchalis ranges over the tracks bounded in the south by the distribution of Platypeltis ferox, and in the north by Amyda mutica and Aspidonectes spinifer. I have received the specimens mentioned above too late to cause any of them to be represented upon my plates.

ASPIDONECTES EMORYI, *Ag.* The first intimation I had of the existence of another species of Aspidonectes within the boundaries of the United States was from the sight of two eggs collected in Texas by Dr. Heerman, and presented by him to Dr. Holbrook, who gave them to me. These eggs (represented in Pl. 7, fig. 20) were so much larger than those of either of the three other species of the family which I then knew, that I did not hesitate to consider them as derived from an unknown species. My supposition was very soon changed into certainty, after I had received from the Smithsonian Institution all the specimens of Turtles collected in Texas during the operations of the Boundary Survey, under the command of Col. Emory, among which were young and adult specimens of this species, collected in the lower Rio Grande of Texas, near Brownsville. I take great pleasure, therefore, in dedicating this species to that distinguished officer. I afterwards received some more young specimens from Mr. G. Stolley, collected in Williamson County, Texas, in a stream emptying into the Rio Brazos.

This species is very readily distinguished from the two preceding by the absence of prominent spines along the front margin of the carapace, where a single row of small tubercles is visible, and by the greater width of the hind half of the shield, the upper surface of which is dotted all over with small whitish tubercles, like grains of sand, arranged in longitudinal rows along the posterior part of the vertebral column, and diverging somewhat upon the sides, upon a uniform greyish ground, without ocelli or blotches. These tubercles are somewhat larger in adult specimens than in the young. The pale rim of the hind margin is much broader than in any other species of the family. In young specimens, (Pl. 6, fig. 4,) that rim is separated by a distinct black line, which afterwards fades; the white tubercles are also encircled by faint black lines, which soon disappear. The whole lower surface is white, except dark lines along the inner surface of the fingers. The upper surface of the legs and the upper part of the neck and of the head are marked with small black dots. A white line extends behind the eyes, and fades into the white sides of the neck. A straight black line extends in front of the eyes across the space which separates them, and forms a triangle with two similar lines extending from each eye to the tip of the proboscis. The largest specimen I have seen, measured twelve inches from end to end of the carapace, and nine and a half across the middle. All the specimens I have examined thus far were obtained in Texas. Rev. Edward Fontaine, of Austin, Texas, writes me that it delights in clear, bold, and rocky streams, and possesses nothing of the sluggishness of other Testudinata, but is brisk and vivacious in all its movements, running rapidly on land when dropped from the hook of the angler, and swimming with great velocity.

I expect to be gravely criticized for describing the species of our Trionychidæ in the manner in which it has been done in the preceding pages. Seeming discrepancies may, indeed, be noticed between the generic and specific characters of these Turtles as expressed here, and the description of the family characters as presented in a former section. But Animal Morphology has still more striking contradictions in store in its nomenclature, than those of which I may have been thus far guilty. So long as our language has not yielded to the necessities of the case, there will be something awkward in the use of expressions that are familiarly employed to designate definite forms, when transferred, with qualifications, to animal forms, which have neither the definiteness nor the regularity of mathematical figures. It may appear absurd to speak of a flattened sphere, of an elongated circle, (not an ellipse,) and the like; but I hold that it is better to make such a use of these words than to avoid apparent contradictions by the introduction of circumlocutions; for such expressions are at once characteristic, and may become quite picturesque when judiciously applied. The family of Naiades among Acephala has afforded me a welcome opportunity to test the importance of form, as the leading character of families. There is scarcely another natural group which embraces species apparently more diversified in their forms than these shells. We need only compare Unio stegarius with U. rectus or Shepardianus, or U. alatus with U. cylindricus, or with U. Cardium or U. torsus or U. mytiloides, triqueter, flexuosus, etc. Every possible form seems to be represented in that family, from the quadrangular or triangular to the spherical. And yet all Naiades have one and the same typical form, determined by their internal structure, which may be described as ovate, with a double flexure on the lower side, towards the hind extremity; and this form is determined by the structure of the mantle.[1] Unio flexuosus exhibits this typical form in its most distinct out-

[1] I shall have an opportunity to illustrate these statements most fully in a future volume, probably the fifth, which is to be devoted exclusively to the history of our fresh-water Mussels.

lines, but so far exaggerated as to appear one of the most aberrant representatives of the whole family; whilst it is so subdued in the most common species as hardly to be perceptible. This being the case, I feel justified in saying, that whosoever does not see that all Naiades have the same form, is still as far behind in Animal Morphology as the tyro in Geometry, who could not understand that the circle may belong to a series of which the straight line would be an extreme case, and again form another series with the ellipse, the parabola, and the hyperbola; with this fundamental difference only, that all these forms belong to an unstable equilibrium in the organic world, whilst they have fixed relations in the inorganic.

SECTION VI.

THE GENERA OF CHELYDROIDÆ.

I know only three genera belonging to this family, and am not aware that there exist others even remotely allied to them. These are the genus CHELYDRA, *Schw.*, the genus PLATYSTERNUM, *Gray*, and the genus GYPOCHELYS, characterized in this work for the first time. The genus CHELYDRA was characterized by Schweigger[1] in 1812; Fleming[2] called it Chelonura in 1822; Latreille[3] called it Saurochelys in 1825; in the same year J. E. Gray[4] gave it the name of Rapara; and in 1835, Duméril and Bibron,[5] overlooking the many names already proposed by their predecessors, insisted upon giving it another new one, Emysaurus, which they spell also Emysaura, and which has occasionally been further quoted under the form of Emydosaura.[6] The genus PLATYSTERNUM was first characterized by J. E. Gray[7] in 1831. Though I never had an opportunity myself of examining this last genus, I have no doubt that it belongs to the family of Chelydroids; and the descriptions and figures given by Gray, and Duméril and Bibron,[8] furnish satisfactory evidence of its true relations. This being the case, it is interesting to notice how widely apart from one another the few living representatives of this family are found upon the surface of our globe. Platysternum with one species, in China; and Chelydra and Gypochelys, each with one species, in North America. But this singular geographical distribution acquires a special interest when it is further stated, that the American genera Chelydra and Gypochelys are only met with on the east-

[1] In the work q. a., p. 394, note 5.
[2] In his Phil. Zoöl., vol. 2, p. 270.
[3] Familles naturelles du Règn. An.
[4] Ann. of Phil., 1825, vol. 10, p. 210.
[5] Erp. gén., vol. 2, p. 199, and 318.
[6] Cat. Brit. Mus., 1844, p. 34.
[7] Proc. Zoöl. Soc., London, 1831, p. 106.
[8] Erp. gén. Pl. 16, fig. 2.

ern side of the American continent, and not at all to the west of the Rocky Mountains, or even in their immediate vicinity; since we cannot fail to see, in this apparently anomalous distribution, another instance of the remarkable similarity, pointed out by the founder of the Physical Geography, between the eastern or western shores of our continents when respectively compared with one another, in their physical features, and in the character of their inhabitants.

There is another fact of general interest connected with this family, — its existence in Europe, in past geological ages, while no trace of these Turtles can be found there now. The fact is well authenticated: two very distinct species of Chelydroids, from the Miocene beds of Oeningen, near the Lake of Constance, have been described and handsomely illustrated by Th. Bell[1] and Herm. von Meyer.[2] But what is the meaning of such a phenomenon? I am inclined to think that the early introduction of this family, in Europe, during the Tertiary period, became an inducement for their reproduction, in a later age, upon other continents, one of which, at least, bears every characteristic of having been, long before Europe, and for ages past, essentially what it is now, as far as its physical features are concerned. I would, therefore, suggest that America has among its Testudinata old-fashioned types, because it is the oldest continent, and not because Chelydra is any more characteristic of the American fauna than of the European. I shall presently call attention again to this point.

The eggs of the Chelydroidæ, like those of the Trionychidæ and Chelonii, are spherical; but they are liable to occasional variations, those of Chelydra serpentina at least, for I have twice obtained ovate eggs from their nests, and once found an ovate one in its ovary (Pl. 7, fig. 25). Among the spherical ones (fig. 24 and 26) there is also some variation as to size, and to a less extent respecting the hardness of the shell. I have no reason to infer from these facts that the eggs of Testudinata are generally liable to great variations, because the family of the Chelydroidæ stands, as it were, between the lower families with spherical eggs and the higher families with ovate eggs, and we should expect a stronger tendency to unusual combinations in animals holding such a position than in others; though it must not be forgotten that there is also some disposition to vary among the eggs of the families in which they are oval, and that the highest Testudinata lay spherical eggs like the lowest. This last fact seems to me strongly to vindicate the view which I have already expressed, that the Testudinina are not absolutely higher than the other natural groups of this type, and cannot, therefore, be considered in the light of a sub-order coequal with the Chelonii proper. (Compare p. 249.)

[1] Proc. Geol. Soc., London, 1831.

[2] Zur Fauna der Vorwelt., 1 vol. fol.

The young of the family of Chelydroidæ exhibit new features, different from those which we have noticed before in sea Turtles, in Emydoidæ, and in Trionychidæ. When hatched, they start, like the Trionychidæ and Emydoidæ, with a circular body; but their body is relatively much higher than that of the Trionychidæ and Emydoidæ, and flattens out with age. The circular form grows first more and more oval, then oblong, in Gypochelys, (Pl. 5, fig. 23–27,) by a straightening of the lateral margin; while in Chelydra (Pl. 4, fig. 13–16, and Pl. 5, fig. 18 and 19) an oval circumference is permanent throughout life. The ornamental bass-relief which appears upon the surface is not less peculiar in Chelydroidæ. In Gypochelys it exists all over the body; in Chelydra particularly on the upper shield, where the corium rises in the form of larger and smaller warts and ridges. Besides smaller warts, which are spread irregularly all over the body in Gypochelys, and over the shield in Chelydra, we see in both genera three rows of longitudinal ridges formed by the median and the two costal plates of the back. These ridges are homologous to the three longitudinal rows of the young Thalassochelys and of the genus Chelys. The homology of Gypochelys with the latter genus is even carried so far, that, in the adults, the horny plates as well as the corresponding bony shields, when only seen from above, could hardly be distinguished. Even that curious twisting, characteristic of the lateral ridges, is the same in both cases, and the sutures between the costal plates run through them in exactly the same places. We see here a homology of forms connected with the greatest discrepancy of structure; for the true skeleton of Chelys, taken as a whole, is so different from that of the Chelydroidæ, as to justify fully their separation as distinct families.[1] Beyond these three ridges, we find, in the young Gypochelys, two more ridges on the top of the marginal plates. These are wanting in the young and in the adult Chelydra, and nearly so in the adult Gypochelys. Moreover. in the adult Chelydra, the three median ridges fade also more and more with advancing age, and we have seen large adult specimens which were entirely smooth. The lateral and posterior marginal plates of the young of this family are narrower outwardly than where they are attached to the costal plates. This causes the circumference of the posterior half of the trunk to appear deeply scalloped in Gypochelys, but less so in Chelydra, where these indentations disappear more and more with advancing age. At the first sight, the tail would seem, on account of its great size, to be an organ adapted for similar functions as in young Emydoids, in which we found it also relatively very long; but upon closer examination we may soon be satisfied that the round, strong tail of the Chelydroids. though very long, is not a rudder as in young Emydoids, but a support in walk-

[1] See the family characters of Chelydroidæ and Chelyoids, p. 335–346.

ing, or in attacking their prey and in defending themselves. The Chelydroids make the same use of their tail when adult. The long tail of the young is therefore typical here, and not an embryonic feature, as it is in the Emydoids. The Chelydroidæ are mud Turtles; they walk on the mud, or on the bottom of the water, and, when put into the water, they instantly dive to the bottom. Nevertheless, in this family, the feet are also better adapted for swimming in the early part of life than later; at least, the web between the toes is thinner, and thus the toes more movable than in the adult. This is particularly obvious when comparing the hind feet of the young Gypochelys with those of the adult; for in the latter they are heavy, bulky, plantigrade, walking feet.

Most of the characters which we have considered thus far are common to the two American genera of Chelydroidæ, Chelydra and Gypochelys. But there are already features, in the young of the first year, which constitute generic differences. This is particularly evident in the head and tail. The head of the young Gypochelys exhibits already fully that wedge-shaped eagle bill, running sharply down in front, by which it is so clearly distinguished from Chelydra when adult; while, in the young Chelydra, the head is already much shorter, and the jaws more rounded. Again, the tail distinguishes them also when young most strikingly; its lower surface, in Gypochelys, being covered with many small more or less imbricated scales, just as in the Anguiformes among Lizards, while in Chelydra, as in most Snakes, there run all along the under surface of the tail, two rows of large scales. In Lizards and in Snakes, this amounts to a family character, the scales of the tail being there of more importance than in Turtles, in which we can only recognize generic differences in their peculiarities.

The American members of this family are divided into two strongly marked groups, one comprising the genus Gypochelys, the other the genus Chelydra. These groups have clearly defined generic characters; but it is a question, whether some of their distinguishing characters have not a more than generic value. The elements of form are in general the same in both; but there are wide differences in the forms of the head, which are, perhaps, such as to make each group a sub-family.[1] In Gypochelys every thing about the head is fitted to give the

[1] Whether the family of Chelydroids contains two sub-families or not, there can be no doubt that its North American representatives belong to two distinct genera. It will be easier to settle the question of the sub-families after an opportunity has been had to compare carefully the genus Platysternum. It may seem immaterial to ascertain this point, when it is considered that the whole family numbers only three genera. But, if the principles which I have advocated in the first part of this work are correct, it will be found that Platysternum will either be intermediate between Chelydra and Gypochelys, in which case the family would not be subdivided, or Platysternum will lean more towards one or the other of the American genera, in which case it would at once appear that it embraces two distinct sub-families.

greatest force to the bite of the animal: the mouth is narrow; the jaws are strong; and their muscles are enormously developed, forming the great bulk of the head. In Chelydra the mouth is broader, the jaws are not so strong, and their muscles are less developed. Upon this general difference depend most of the distinguishing characters of the two groups.

I. Gypochelys, *Ag.*

The skull of Gypochelys is very broad and high at the hind end, and rapidly grows narrow and low thence forward; that part which includes the mouth and eyes and nose being very small in comparison with that which includes the fossæ temporales. The upper surface is nearly horizontal from side to side, and meets the sides at sharp angles; it descends steeply from behind forward till between the eyes, where it makes an angle, and thence to the front end it is nearly horizontal; it narrows continually forward from where it first reaches entirely across the head, but is still broad between the eyes, and blunt at the front end. The sides spread outward somewhat towards the lower edge between the ears and eyes, (that is, over the fossæ temporales,) and thus the head grows broader downward; but, in front of the fossæ, the head is broader across the upper surface than across the mouth below. The eyes open sidewise and forward, not at all upward; the sides of the nasal region in front of the eye are nearly vertical; and the outer surface of the jaw is turned inward toward the alveolar edge, except at the symphysis, where it is on a nearly vertical line with the end of the nose above. Thus the mouth is narrow. The nasal region is high, and flattened sidewise. The upper jaw, at the symphysis, is drawn down to a long, strong point. On each side of this point the alveolar edge rises steeply, then curves down under the eye, and again a little upward at the hind end. The alveolar surface is carried high up under the nose, so as to form there an inverted, deep, conical pit. The pterygoids are narrow between the muscles of the jaw. The lower jaw is high and strong; and, like the upper one, it is drawn out at the symphysis to a long, strong point, which rises higher than the coronal angle. The outer surface, at the symphysis, curves far inward in descending from the upper to the lower edge, and, when the mouth is closed and the point of this jaw carried to the top of the pit above, there is a large space in front of this surface between it and the inner surface of the upper jaw. The strength of the jaws, the height of the lower one, the height of the head over the mouth, the narrowness of the mouth itself, and the height and width of the back part of the head, are all clearly connected with the force of the bite of the animal. The neck is shorter than in Chelydra; this is owing to the size of the head; for such a head on a long neck would be cumbersome. The three ridges along the carapace are largely developed, and neither of them vanishes with age. The marginal rim is thick, projecting far out beyond the carapace at the sides; and at the front end it is deeply arched backwards, which is necessary to allow free motion to the large head. One scale covers the whole nose, above the horny sheath of the jaw. There is a characteristic row of scales, three in number, situated between the costal and marginal rows, over the union of the carapace and plastron, the addition of which is perhaps due to the great thickness of the marginal rim at that place, and two scales on each of the bridges of the plastron, within the row of three which crosses the ends. The whole neck and chin are covered with horny papillæ of various sizes and forms.

GYPOCHELYS LACERTINA, *Ag.*[1] Sufficient references to this species have already been given (p. 250). Its geographical range extends from western Georgia and north-western Florida, through Alabama, Mississippi, and Louisiana, to Texas. But I do not know exactly how far north it may be found in the valley of the Mississippi. I have lately received another young specimen from the neighborhood of New Orleans, through the kindness of Dr. Benedict, and compared other specimens from Mississippi, sent by Professor Wailes to the Museum of the Essex Institute in Salem, and also one belonging to the Museum of Oxford, Mississippi. Mr. Robert H. Gardiner has sent me one from south-western Georgia. They all agree in their generic and specific characters, and fully sustain the first observations of Dr. Holbrook.[2] According to Professor Wailes, it measures sometimes three feet in its greatest diameter. I insert below some interesting remarks respecting its habits, which have lately been communicated to me by Rev. Edw. Fontaine, of Austin, in Texas, who first observed it in that State.

"I often have encounters with them when fishing for bass in our prairie rivulets. I saw one lying dead on the margin of a lake in Panola County,

[1] As this species is unquestionably the Chelydra lacertina of Schweigger, (Prodr., q. a.,) the specific name of Gyp. Temminckii, proposed by Troost and Dr. Holbrook, and adopted, p. 248, must give way to the older one, introduced by Schweigger. I am well aware that Duméril and Bibron distinctly state (Erp. gén. vol. 2, p. 354) that Chelydra lacertina, *Schw.*, is only founded upon an overgrown specimen of Chelydra serpentina; but these very specific names show that Schweigger not only knew the two species of Chelydroids which inhabit the United States, but also perceived the differences in the scales under the tail, which distinguish them, and upon which I have insisted, (p. 412,) as generic characters; and that he was aware how these peculiarities compare with the scales of Serpents and Lacertians.

[2] North American Herpetology, vol. 1, p. 147, pl. 24. Dr. Holbrook describes it under the name of Chelonura Temminckii; Duméril, Cat. Rep. of the Jardin des Plantes, calls it Emysaurus Temminckii, adding, that he had already distinguished it in his manuscript, as E. lacertina. Compare, however, note 1.

Mississippi, made by an old bed of the great river, which measured nine inches between the eyes. I took no other measurement of its dimensions, and had no means of weighing it; but I am confident it would have weighed more than a hundred pounds. I saw the skull of one much smaller, caught by a gentleman in the same county, which weighed seventy-five pounds. I have seen none of half that size in this vicinity. I kept two for several years in my fish-pond. They became very tame, but finding they were eating my fish I shot one, and wounded the other with a fish-gig; but his sagacity prevented my capturing him. I fed the perch and minnows with bread, which the alligator turtle[1] devoured greedily. One day, after he had eaten, he remained upon the rock where I had fed him, and which was only about a foot beneath the surface, where it shelved over water ten feet deep. A swarm of minnows and perch were picking up crumbs around him, apparently unconscious of his presence. His head and feet were drawn sufficiently within his shell to be concealed. His mossy shell could not well be distinguished from the projections of the rock, on which he was lying in ambush. Several large bass were gliding around him, occasionally darting at the minnows. One of these, about fourteen inches in length, came within striking distance of his head, which he suddenly thrust out and fastened upon him, fixing his aquiline bill deeply into his side and belly. He immediately drew the fish under him, and, holding him down firmly to the rock with his forefeet, ate him greedily, very much as a hawk devours its prey. I drew out a large line and hook and baited it with a minnow, and threw it to him, determined to get rid of this skilful angler. He seized it; I gave a sharp jerk, and fastened it in his lower jaw. Finding him too heavy to lift by the hook upon a rock six feet perpendicular, I led him around to the lower end of the pool, where the bank was low, and the water shallow. But, after getting him within a few feet of the edge of the water, he anchored himself by stretching forward his forefeet, and resisted all my efforts to get him nearer. He seemed to be in a furious rage, and, after several sharp snaps at the line, he broke the hook and retreated into the deepest part of the pool. I never could get him to bite at any thing afterwards; and, finding I had a design upon his life, he became very shy. I afterwards discovered him in deep water, eating the bread which fell from the shelving rock, on which he had fed for several years, but upon which he never ventured afterwards when I was near. I threw a gig at him, and fastened it in his neck; but, by a violent effort with one of his forefeet, he tore it loose and ran under the rock. I frequently saw him after his escape, but always in the act of retreating to his hiding-place, which was

[1] This is the name given to this species in the Southern States.

entirely inaccessible. I intended sinking a steel-trap, baited with beef, to secure this sagacious old fellow, but my removal to the city side of the Colorado probably saved his life; and I have but little doubt he yet lives and thrives upon the numerous fishes I left with him. If these two turtles made a nest or deposited their eggs while I had charge of them, I never discovered it. They kept all their love for one another, and their domestic affairs, a profound secret from their master. This species has a strong musky smell."

A comparison of the young, (Pl. 5, fig. 23–27,) and of the eggs, (Pl. 7, fig. 27,) with those of Chelydra serpentina, (Pl. 4, fig. 13–16; Pl. 5, fig. 18, 19, and Pl. 7, fig. 24–26,) will suffice to show the difference between these two remarkable Turtles. The color of Gypochelys lacertina varies from a light reddish or yellowish brown to an almost black tint.

II. Chelydra, *Schw.*

The head is smaller in Chelydra than in Gypochelys, the difference lying mostly in the relative size of the muscles which move the jaw, for the mouth is much broader here than in Gypochelys. The upper surface does not, as in Gypochelys, make an angle and lessen its descent in passing forward to the region of the eyes, but continues with one slope from the hind to the front end. The bony covering of the head, back of the eyes, is a low, flattened arch, spread out widely below, the sides making a very slight angle with the upper surface. The head widens downward also at the region of the eyes, and the orbits are near together at their upper edges and wide apart below, so that the eyes look upward as well as forward and sidewise. The upper and hind edges of the orbits project considerably beyond the skull, just between and behind them. The spreading apart downward of the sides of the front part of the head makes the mouth very broad. The nasal region is short, not high and flattened sidewise, as in Gypochelys, but rounded and conical, with the front end truncated. The outer surface of the jaw, at the front end, slants backward from the nose to the alveolar edge. The alveolar edge is prolonged downward at the symphysis to a small point; and on each side of the point the curve of the sides of the nasal region is continued down to the edge, and makes a short depression in it: the edge curves down only slightly under the eye. The pit, in the alveolar surface at the front end, is very small. The pterygoids are broad between the muscles of the jaw. The lower jaw, like the upper one, is spread wider, and is lower and not so strong, as in Gypochelys. Its alveolar edge is pointed at the symphysis; but the point is very small, and reaches no higher than the coronal angle. The ridges along the carapace are here less developed than in Gypochelys, and almost disappear late in life. The marginal rim projects only slightly at the sides beyond the carapace; its front end is much less arched backward than in Gypochelys. There are a pair of scales on the nose, above the horny sheath of the jaw. There is no row of scales between the marginal and costal rows. The scales on the plastron are less numerous than in Gypochelys; one large one covers the whole bridge inside of the row of three which curves its outer edge. There are only two papillæ under the chin.

CHELYDRA SERPENTINA, *Schw.*[1] This is the well known Snapping Turtle of the United States, one of the most widely distributed species of this continent. It is found from Canada and Maine to Florida, and westward to the Missouri and to Louisiana. I have seen specimens from Ohio, from Indiana, from Iowa, from Missouri, and from Tennessee, not to speak of the Eastern and Middle States, where it is everywhere common; but I still entertain some doubts as to the identity of the specimens from the Southern States.[2] The color varies from light to dark brown. Its growth is much more rapid during the first ten or twelve years of its life than afterwards, as may easily be ascertained by a comparison of the relative distance of the lines of growth in the centre and at the edge of the scales of adult specimens.[3] It is reported, upon reliable authority, that a specimen, marked forty-five years ago, only increased one inch in that time.

The fossil species referred to the genus Chelydra seem to belong to two distinct genera, resembling more closely in some respects the genera Chelydra and Gypochelys, while in other respects they are more closely allied to Platysternum, judging from the greater width of the anterior end of the sternum in Chelydra Murchisoni, and of the posterior end in Ch. Dechenii.[4]

[1] Although Linnæus mentions Algiers and China as the home of his Testudo serpentina, there can be no doubt that it is our species, and that he was mistaken as to its origin, the genus Chelydra being exclusively North American. Pennant mentions it as Testudo serrata, and Shaw as Testudo longicauda. The names under which it is most frequently quoted are Chelydra serpentina, Chelonura serpentina, and Emysaurus serpentinus.

[2] Specimens from Mobile and New Orleans show a wider emargination between the middle pair of the marginal plates of the hind margin than northern ones, and the keels of the back are less prominent. There are some other differences in the scales upon the bridge between the plastron and the shield; but I have not seen a sufficient number of specimens to be positive that all those found at the south agree in this respect, and constitute a distinct species. At all events, however, it is a remarkable variety, which does not occur at the north, and which I shall label *Chelydra emarginata* in my collection, until I have better opportunities of ascertaining the value of the differences thus far noticed.

[3] Judging from the lines of growth, specimens six and a half inches long and five and a half inches wide are only twelve years old; while others, which measure not more than twelve inches in length and nine and a quarter in width, are at least thirty-eight years old.

[4] Chelydra Murchisonii, *Bell*, (Trans. Geol. Soc. Lond., 2d ser., vol. 4, p. 279, pl. 24; H. von Meyer, zur Fauna der Vorwelt, p. 12, pl. 11 and 12, and Pa-

SECTION VII.

GENERA OF CINOSTERNOIDÆ.

Our knowledge of the genera and species of this family has progressed very slowly. For a long time only two species were known, which remained mixed up in the genus Terrapene with other species belonging to very different genera, until Fleming distinguished the genus Cistudo, Spix the genus Cinosternum, Bell the genus Sternothærus, and Wagler the genus Staurotypus, among which all the species thus far included in the genus Terrapene were at once divided, and new ones added. But, even after this first repartition of the species into several genera, much confusion continued to prevail in the nomenclature, as well as in the characteristics, of these animals. The name Terrapene, introduced in our science by Merrem, in 1820, to include all the fresh-water Turtles with a movable sternum,[1] was limited, in 1825, to the Box Turtle, Cistudo, by J. E. Gray,[2] while Bell still united heterogeneous species under that name.[3] About ten years later, Canino applied the name Terrapene exclusively to the North American Emyds, and very properly retained the name Emys[4] for the European species, to which it had been applied from the time of the first dismemberment of the old Linnæan genus Testudo. The genus Cinosternum was from the beginning circumscribed within natural limits by Spix,[5] and maintained within the same limits by

læontogr., vol. 2, p. 238, pl. 26, 27, and 30,) has the front end of the plastron widened, as in Platysternum, while the posterior end is pointed, as in Chelydra. In Chelydra Dechenii, *Myr.*, (Palæontogr., p. 242, pl. 28, 29, 30, fig. 5 and 6,) the case is exactly reversed. It is thus plain, that, while at the time of their first appearance upon earth the representatives of this family were not constructed exactly as they now are, they yet foreshadowed, in the combination of their characters, the peculiarities that distinguish the living genera, two of which occur in North America and one in China, though none are found where the type first originated.

[1] Besides two species of Cinosternoidæ, (Terrapene Boscii and odorata, which are one and the same species, now called Ozotheca odorata, and Terrapene pennsylvanica and tricarinata, which are also identical, and belong to the genus Thyrosternum,) the genus Terrapene, as limited by Merrem, (in his Testamen Systematis Amphibiorum, Marburgi, 1820,) embraces a genuine Sternothærus, Terrapene nigricans, and two Cistudos, Terrapene clausa and amboinensis.

[2] Genera of Reptiles, in Ann. of Phil., vol. 10, p. 211.

[3] Monograph of the Tortoises having a movable sternum, in Zool. Journ., vol. 2, 1825, p. 299. In this paper Bell still unites the European Emys with the North American Cistudo as one genus, under the name of Terrapene.

[4] Chelon. Tab. Anal. 1836. In 1830, Wagler had already retained the name of Emys for the European species; but, like Bell, he still associated with it the Cistudos, which were at last duly distinguished by Canino.

[5] SPIX, (J. B.,) Species novæ Testudinum et Ranarum, Monachii, 1824, 4to.

Wagler, Duméril and Bibron, Fitzinger and others, while Gray[1] unites Cinosternum and Staurotypus as one genus. The genus Sternothærus, on the contrary, has undergone many successive alterations. When first distinguished by Bell,[2] it contained, besides its true representatives, a species also that belongs to a different genus, which I have called Ozotheca.[3] Wagler having unfortunately introduced another name, Pelusios, for Bell's Sternothærus, the latter was inappropriately limited by Fitzinger to Terrapene odorata, whilst Duméril and Bibron[4] referred this species to Wagler's genus Staurotypus,[5] which ought, however, to embrace only its original type, the St. triporcatus. All the Cinosternoidæ are American.[6]

The assumption that the movability of the sternum[7] indicates a close affinity among these Turtles has, to this day, prevented herpetologists from perceiving the family characters which distinguish the true Cinosternoidæ from the Emydoidæ, and likewise separate them from Sternothærus, as shown above in the description of these families.[8] Among the many fossil Testudinata thus far described there is not a fragment indicating that the family of Cinosternoidæ has existed in earlier periods. This is the more surprising as its nearest relatives, the Chelydroids and the Emydoids, are well known to have existed in past ages. There is, however, a peculiar character prevailing in the family of Cinosternoidæ, which it is difficult to express with precision, but which may yet account for their absence. Most types of animals and plants, when making their first appearance upon earth, are either marked by striking peculiarities, that make them stand out boldly among their contemporaries on account of their great difference, or they exhibit characteristics, in which the prominent features of later types are more or less blended together. Nothing of the kind exists in the Cinosternoids. On the contrary, they are, as it were, abortive Testudinata,—dwarfish in size, abrupt and quick in their feeble movements, seeming young when full-grown; and yet, assuming very early the characteristic features of the adult, they are everywhere in the country mistaken for young Chelydroids. In all the species of which I had an opportunity to examine numerous specimens I noticed marked differences between the males and females, consisting chiefly in the form of the front part of the shield, in the length of the tail, and in the scales of the legs.[9]

[1] Cat. Brit. Mus., 1834, p. 34.

[2] Zool. Journ., vol. 2, p. 305.

[3] Compare p. 251.

[4] Erp. gén., vol. 2, p. 358.

[5] WAGLER, Nat. Syst. d. Amph., p. 137.

[6] Compare p. 302.

[7] Compare p. 346 and 418.

[8] See p. 346. Nothing can prove more directly the importance of a careful discrimination between family and generic characters than the changes which the classification of these genera has undergone.

[9] The difference in the form of the shield consists in the greater width of its front part in the female. The tail of the male is much longer and stronger than that of the female. There is, in the male, a patch of rough scales in the bend between the thigh and the leg.

The characteristic peculiarities of the eggs of the Cinosternoidæ have already been mentioned (p. 350). Those of Thyrosternum pennsylvanicum are represented Pl. 7, fig. 1–6; those of Ozotheca odorata, fig. 7–9.

In the young Ozotheca odorata, and still more in the young Thyrosternum pennsylvanicum, the characteristic features and forms of the family are already so fully developed during the first year, that we can hardly point out any change in their forms, from young to adult. This holds good, not only for the general proportions and outlines of the upper and lower shield, the feet, and the tail, but also for the scales. In the adult Emydoidæ, as well as in the Cinosternoidæ, the median scales of the carapace are generally narrower than the costal ones. This is already fully the case in all Cinosternoidæ, at the time of hatching; while in Emydoidæ exactly the reverse obtains. (See p. 293, note 1, for a description of the young Chrysemys, and also Pl. 4 and 5.) In Thyrosternum, Platythyra and Ozotheca, the median scales of the back are, from the first year, not broader than long; while in Emyds they are at least twice, and often three times as broad during the first year as later in life. This peculiarity no doubt contributes to give them an oldish appearance from the beginning. There is another feature which makes the young Cinosternoidæ look old: the rounded margin of the carapace and its steep curve behind, which are already fully marked, during the first year, in Thyrosternum and Platythyra. The sharper margin and the less prominent curve, which characterize Ozotheca in contradistinction to Cinosternon, are likewise strongly marked in the young Ozotheca, even more strongly than in the adult. Moreover, the tail has the same proportions from the first year to adult age. As the Cinosternoidæ are walking Turtles, living in mud like the Chelydroidæ, they do not need a long and high tail as a rudder. Notwithstanding this early development of the prominent features of these Turtles, we have to point out one interesting change in the Ozothecoids. When young, they are all high and carinated. These characters are brought out most fully in Goniochelys triquetra; while Ozotheca odorata, which, when young, shows the same height and the same keel on the back, grows more and more flat in course of time.

The family of Cinosternoidæ is composed of two well defined groups. In one, the true Cinosternoids, the plastron is large, and underlies nearly the whole body; the bridges which connect it with the carapace are long, and the first and fourth pairs of its bony plates are broad and rounded, and connected with the intermediate pairs by very flexible hinges. Thus the spaces around the free edges of the plastron are small, and, when the animal withdraws and raises the ends of the plastron, the soft parts of the body are almost entirely protected. In the other group, the Ozothecoids, the plastron is smaller; the bridges are shorter, and descend less below the carapace; the fourth pair of bony plates is narrower at its front end, and narrows continually thence backward, its sides being straight, and not curved outward, as in the first group; and the sutures of the first and fourth pairs, with the second and third, are but slightly movable in the adult, and in some cases not at all so. Thus the spaces around the free edges of the plastron are here larger than in the first group; and besides, the protection from the shield is still less on account of the slight movability of the parts of the plastron upon one another. There are, besides, certain other tendencies that become important in connection with their constant characters. In Cinosternoids the tendency is to a more regularly arched carapace; in Ozothecoids, to a sharp ridge along the back, the sides spreading wide apart downward, so that the body is generally broader between the outer edges, but less deep below them, than in the first group. The scales on the plastron of the Cinosternoids are well developed and well defined, and cover its whole surface; but in the Ozothecoids they are more irregular, and often separated by large, scaleless spaces between them; and the fourth pair of bony plates reaches forward on to the third pair, which is never the case in the Cinosternoids, for there it would interfere with the motion of the hinge. The scales of the shield differ also; in Ozothecoids they have a marked tendency to overlap those farther back, the centre of growth receding gradually backward of the centre of figure, as in the Chelonioids, and some exhibit even distinct traces of imbrication. In both groups there are two or more horny papillæ under the chin. The principal differences between these groups all go to bring the body more under the protection of the shield in Cinosternoids than in Ozothecoids, and to give the legs freer motion in the latter than in the former. These characters are easily traced to corresponding habits of these animals; for, at least as far as we are acquainted with the members of these groups, the Cinosternoids resort, in danger, more to the shield, the Ozothecoids, to flight; the former live more on land, the latter more in deep water, and are also the more shy, and the quicker in their motions. These characters, thus connected with the general form, and impressing upon it such decided tendencies, are clearly sub-family characters, and the groups themselves are sub-families.

Within the limits of each of these sub-families of Cinosternoids, minor groups, containing one or more species, may be distinguished, that differ in the structure of the jaws and the parts dependent upon them, in the way of taking food, and, to some extent, in the kind of food sought; in short, in the voluntary organs of nutrition, and the parts concerned in it. At first sight, these groups, based on one set of organs, may seem arbitrary; but if it is remembered to what extent the acts of animals are directed to getting food, how far their sensations are gratified by this act, and how largely their instincts are concerned in it, it will be plain that the characters of the immediate instruments of these acts are essential characters, and that any peculiarities and identities among them must be important in determining their natural relations. In Turtles the jaws and the neighboring parts are the principal organs concerned in these acts; and the claws and limbs, which generally perform so large a part in the movements connected with the function of nutrition in some of the higher types, have here little or nothing to do with it. Moreover, in Turtles the structure of the jaws and their muscles determine, to a great extent, the structure and form of the whole head. About the jaws and head, then, are we to look, in this order, for the structural characters which belong to the voluntary acts relating to nutrition; and here, and here only, do we find the distinguishing characters of the natural groups that may be distinguished within the families and sub-families. Months of research in the family of Cinosternoidæ, and in corresponding groups of other families, have failed to point out any other organs as bearing distinctions and characters for these groups. Indeed, leaving out specific characters, it is impossible to identify any other part of the body of these animals, when examined isolatedly, as belonging to one or the other of these groups.[1] It thus appears that there are, among Turtles, natural groups founded upon the organs with which these animals take their food, and upon them only. These groups, unquestionably, are genera.

In preceding families I have not hesitated to insist at once upon the generic value of similar characters, trusting that the similarity in the range assigned to the genera which I was led to adopt upon such a foundation, with other genera already acknowledged as such, would not fail to convey the same conviction to the minds of other naturalists. But, the Cinosternoidæ are to this day so imperfectly known, the genera proposed by the ablest herpetologists are still so unsatisfactorily characterized, and, above all, the opinion expressed by Schlegel and Temminck[2] upon these Turtles is so diametrically opposed to the results to which I have been led, that I felt it indispensable to show, on this occasion, in what way, and by what evidence, I have satisfied myself, step by step, that the family of Cinosternoidæ is a natural family, embracing two distinct sub-families,[3] each of which

[1] I mean to say, that parts of the body of a Turtle found separated, as is mostly the case with fossil remains, cannot be referred to their genus with certainty, unless the jaws be among them; or unless the parts found bear specific characters that occur only in well known genera. This result is of the utmost importance to Palæontology, and may explain why Cuvier did not attempt to determine the generic characters, and to give specific names to many of the fossils which he described. It may also serve as a warning to those palæontologists who never hesitate to distinguish fossil species without sufficient preliminary comparisons with their living representatives, and sometimes upon the most insignificant fragments, which do not exhibit the first specific character.

[2] Fauna japonica; Chelonii, p. 59-62.

[3] Already alluded to, (p. 250 and 251,) when contrasting Ozotheca with the old genus Cinosternum.

numbers several genera, and that its representatives are not all, as the celebrated naturalists of Leyden believe, varieties of only two species of the genus Emys. Of the groups thus distinguished as genera, there are three in the sub-family of Cinosternoids proper, namely, Cinosternum, Thyrosternum, and Platythyra; and three in the sub-family of Ozothecoids, namely, Goniochelys, Ozotheca, and Staurotypus. The colors prevailing in all these Turtles are dark, here and there enlivened by reddish or greenish or yellowish tints.

GENERA OF THE SUB-FAMILY OF OZOTHECOIDÆ.

Besides the Mexican genus Staurotypus, this sub-family embraces two genera that have representatives within the limits of the United States.

I. GONIOCHELYS, *Ag.* The jaws are very strong, and their muscles powerful. The strength of the upper jaw lies in the thickness of the bone; that of the lower jaw lies both in the thickness of the bone and the height of the jaw itself. To give room for the large muscles, the head is very broad across the fossæ temporales. The sides of the head, back of the eye, spread wide apart downward; the roof, between the orbits, is broad, but still they spread apart downward, and therefore open somewhat upward. The sides of the nose curve a little outward in passing down from the top. The jaw, under the eye, is very thick; its outer surface curves outward, and then again turns sharply inward to the alveolar edge; under the sides of the nose that surface slants also far inward; while at the front end it slants backward, but not so much as it does at the sides. At the symphysis the jaw is drawn down more or less, and often considerably, to a point or a chisel edge. The horizontal alveolar surface is very broad, leaving but a small space within its angle. The lower jaw is both thick and high; it is drawn upward at the symphysis to a strong point; its outer surface slants far inward from the alveolar edge at the sides, and backward at the end. The alveolar surface, as in the upper jaw, is very broad, and leaves but little space within its angle; it is broadest at the symphysis, and its inner edge curves somewhat inward in passing back to the hind end. It is nearly flat from side to side just before the angle, but has a ridge descending on to it from the angle. The scales of the shield have a marked tendency to imbrication.

GONIOCHELYS TRIQUETRA, *Ag.* Thus far this species has only been found in Lake Concordia, in Louisiana. I am indebted for specimens to Prof. Baird, Mr. B. Chase, and Prof. Wailes. Several specimens from the same source are preserved in the Museum of the Essex Institute in Salem. The most prominent specific character consists in the very sharp and high keel of the back, and the flat sides, which give it a triangular form, in a front view. I shall describe this and the other new species more fully elsewhere, and give accurate figures of all of them.

GONIOCHELYS MINOR, *Ag.* The geographical range of this species is more extensive than that of the preceding. I first found it in the neighborhood of Mobile; but received afterwards other specimens from Columbus, Georgia, through the kindness of Dr. Gessner. Dr. Benedict also has sent me a specimen from New Orleans, and Dr. Nott others from Mobile. This species differs from the preceding by its smaller size, and more distinctly still by its arched sides, and the low keel of the back. In both species the scales are edged with black, and black lines or dots radiate from the posterior angle of the scales to their anterior and lower margins; but neither of them exhibits the characteristic stripes, which extend from the eyes to the neck, in the genuine Ozothecas.

II. OZOTHECA, *Ag.* The jaws and their muscles are by no means weak, but they are not as strong as in Goniochelys. The alveolar surfaces are not as broad, and the bones of the jaws not as thick, as in that genus, nor is the head as broad across the muscles which move the jaw. The sides of the head converge almost constantly from the ear to the front end; and they arch pretty regularly from above downward, back of the eye, and have no such sharp angles as there are in Goniochelys. The outer surface of the jaw slants inward almost directly from the orbit, and does not curve outward as far as in Goniochelys, if at all, so that the bone there is not so thick as it is in this genus. About the front end, that surface slants backward further than it slants inward at the sides, and the alveolar edge rises there. Thus the nose projects far over the end of the jaw; and this, together with the constant approach of the sides of the head forward, makes the head very pointed in front. The jaw is never drawn down at the symphysis to a point of any size. The vertical alveolar surface is high all round, and is raised up somewhat under the nose; but it is never, either here or in Goniochelys, raised so high as in Cinosternoidæ proper. The horizontal alveolar surface is not nearly as broad as in Goniochelys, and the space within its angle is much larger. The lower jaw is not as thick as in Goniochelys. It is somewhat drawn outward and upward at the front end, not to a point, but to a curved end; its outer surface, at the sides, is nearly vertical; at the front end it curves far back, and this retreating part grows very broad downward. These latter characteristics are not plain till the animal is full-grown. The alveolar surface is not as broad as in Goniochelys; and it widens constantly from each side of the symphysis to the hind end. The ridge, spoken of as descending from the angle on to this surface in Goniochelys, exists also in this genus, but is less prominent, and is often merely a rising of the outer edge. The alveolar edges of both jaws are sharp, and the jaws are in every way well fitted for cutting.

OZOTHECA ODORATA, *Ag.*[1] This is the most common species of the sub-family. Its geographical range is very extensive, extending from New England to South Carolina, Georgia, and Western Florida, and westward to the Mississippi valley, as far as Missouri and Louisiana. I have specimens from Mobile, from New Orleans, from Tennessee, and from western Missouri, which leave no doubt upon this point, and for which I am indebted to Dr. Nott, Dr. Benedict, and Professor Baird. The color varies greatly, from light to dark brown, with or without spots. Major LeConte has described, under the name of Cinosternum guttatum,[2] specimens from Pennsylvania, in which the spots are unusually numerous and distinct. I have satisfied myself, however, by a careful comparison of the original specimen which Major LeConte had the kindness to intrust to me for examination, and of many others from the same locality, (Upper Darby, Pennsylvania,) sent me by Prof. Baird, and from other localities by Dr. Hallowell, that this is a mere variety of our common Ozotheca odorata. I have found similar specimens in Cambridge, among others that varied from a uniform tint to a more or less dotted surface. The young are represented Pl. 4, fig. 1–6;[3] the eggs, Pl. 7, fig. 7–9.

OZOTHECA TRISTYCHA, *Ag.* This species is only found in the Western and South-western States. I have many specimens, collected by Mr. G. Stolley, in the Osage River, in Missouri, and in Williamson County in Texas. Prof. Baird has sent me four young belonging to the Smithsonian Institution, that were obtained by Dr. C. B. Kennerly, near San Antonio, and two others from the Medina River, in Texas. The young are represented Pl. 5, fig. 20–22. Although Ozotheca odorata varies greatly, not only in color, but even in outline, I have no doubt that this is a distinct species, characterized, when young, by the great prominence of the keels upon the vertebral and costal plates[4] and by numerous dark dots between the scales of the sternum, and when adult by a marked difference in the form of the snout. In Ozotheca odorata the snout is much more prominent, on account of the slope of the upper jaw, which extends further back, and is therefore less steep, than in Ozotheca tristycha, the lower jaw of which is broader below the symphysis than in Ozotheca odorata, and suddenly turned up.

[1] This species has been referred to so many genera that it appears, in different works, under more names than any other North American Turtle. Its oldest name is Testudo odorata, which was afterwards changed to Terrapene odorata, Cistudo odorata, Sternothærus odoratus, Cinosternum odoratum, Emys odorata, Staurotypus odoratus. Testudo glutinosa, Emys glutinosa, Terrapene Boscii, and Sternothærus Boscii are other synonymous names. (Comp. Holbr. N. Am. Herp. p. 133, and Duméril and Bibron, Erp. gén. vol. 2, p. 358.)

[2] Proceed. Acad. Nat. Sc., Philad., 1854, p. 185 and 189.

[3] The figure of a young, two years old, shows how the scales increase only along the anterior and lateral margins, thus tending to give them an imbricated appearance.

[4] Comp. Pl. 4, fig. 1–6, and Pl. 5, fig. 20–22.

GENERA OF THE SUB-FAMILY OF CINOSTERNOIDÆ PROPER.

I. CINOSTERNUM, *Spix.* The jaws are strong; their horizontal alveolar surfaces are broad, and they seem well fitted for crushing; their strength comes from thickness, and not from height. The head is very broad: the upper maxillaries spread wide apart backward; the sides of the head continue to spread back of them till about midway between the eyes and ears; and thence backward they approach each other. They also spread rapidly apart from above downward, just back of the eyes. The front part of the head over the mouth is low; its roof between the eyes is broad; and the eye-orbits open sidewise and forward, not upward. The nose is short; its sides curve out somewhat from above downward, and its roof reaches as far forward as the jaw under it. The mouth is very short, and, as the upper maxillaries spread so wide apart backward, it is very broad behind. The outer surface of the maxillaries curves outward under the eye, and then turns sharply inward to the alveolar edge; but at the symphysis the jaw is drawn down to a sharp point or a short chisel-edge, and the outer surface at the end slants backward less than it slants inward at the sides. The horizontal alveolar surface is very broad, narrowest at and near the symphysis, and widening fast thence backward to the hind end. The lower jaw is low, but its outer surface curves far backward from the end and inward from the sides, and its alveolar surface is broad; thus it is thick and strong. The alveolar edge is bluntly rounded at the front end, and not drawn out to a sharp point. The alveolar surface is narrowest at the symphysis and on either side of it, but widens fast thence backward, and is broadest at the hind end; at and near the angle it is almost flat from side to side, but its outer edge rises considerably about the front end. The outer surface of the jaw curves outward considerably below the alveolar edge, thus making the jaws shut the closer.

No species of this genus are known to occur within the limits of the United States; but there are several in Central and South America, which have generally been confounded with the Testudo scorpioides of Linnæus. Major LeConte was the first to distinguish them carefully.[1] It is true the species from the Brazils

[1] Duméril and Bibron, (Erp. gén. 2 vol. p. 32,) as well as Gray, (Cat. Brit. Mus. 1844, p. 32,) agree in considering Bell's Cinosternum shavianum, and Spix's Cinosternum longicaudatum and brevicaudatum, as synonymes of Testudo scorpioides, *Lin.;* but Major LeConte, in his interesting monograph of the genus Cinosternum, (Proc. Acad. Nat. Sc. Phil. 1854, p. 180,) has clearly shown that the Brazilian specimens constitute a distinct species from that of Surinam, which is the old Linnæan species, and that the Mexican is still different. I have myself examined the specimens upon which his descriptions are

was first described by Spix, but under two distinct names. As I have possessed for a long time several living specimens of the species found in Mexico, and of that of Surinam, sent me by Prof. Baird and Mr. C. J. Hering, and compared specimens of the third, I can vouch for the accuracy of the distinctions traced by M. LeConte.

II. THYROSTERNUM, *Ag.* The jaws are strong, and well fitted for cutting, but not for crushing. The head is not as broad as in Cinosternum; it arches back of the eyes, but is not as wide spread as in Cinosternum, and its sides between the eyes and ears are gently curved outward, and have no such sharp angle as in that genus; it is high over the mouth, and its roof there is broad between the eyes, so that the orbits open sidewise and forward, not upward. The nose is long and high; its roof reaches as far forward as the jaw reaches under it, and its sides approach each other downward very fast. The mouth is long and narrow; the outer surface of the jaws curves outward under the eye, and then again turns sharply in to the alveolar edge; and further forward also, under the sides of the nose, it curves far inward, but at the symphysis the jaw is drawn down to a short chisel-edge, and its front surface slants back but little. The vertical alveolar surface is high all round, but especially so at the front end, where it projects downward, and where also it is often raised high up under the nose. The horizontal alveolar surface is broad at the symphysis, and narrowest on each side of it, and widens thence backward; but it is not nearly as broad as in Cinosternum. The lower jaw is strong. It gets its strength, not by its thickness, as in Cinosternum, but by its height. It is very high all round; sometimes it is drawn far up at the symphysis to a long, slender point. The outer surface at the sides is nearly vertical for some distance below the edge. The alveolar surface of the lower jaw is much narrower than in Cinosternum, except at the symphysis, where it is nearly vertical; near the angle it is almost horizontal, but its outer edge rises somewhat. The cutting edges of this jaw pass close within those of the upper

based, and agree with him as to the validity of these species. I have only a few objections to his nomenclature. His Cin. mexicanum is identical with Bell's Cin. shavianum. Bell's description (Zool. Journ. vol. 2, p. 302) is based upon the identical specimen figured by Shaw, from the Leverian Museum, and agrees in every respect with those described by Maj. LeConte, who indeed refers to the same figure of Shaw, also quoted by Bell. (Shaw, Gen. Zool. vol. 3, p. 61, pl. 15, erroneously referred to Staurotypus triporcatus by Wagler.) The name Cin. mexicanum, therefore, must be given up. As to Cin. longicaudatum and brevicaudatum, I disagree with LeConte in one respect, — he considers the two species of Spix as distinct; I believe, with Wagler, (Syst. Amph. p. 137,) that they are the male and female of the same species. Cinosternum cruentatum (Dum. and Bibr., Arch. Mus. 1852, vol. 6, p. 238, pl. 16) belongs also to this genus; but, as I had no opportunity of comparing it with the three others, I am unable to say whether it is a distinct species or not. We have thus at least three distinct species of Cinosternum proper: Cin. scorpioides, *Wagl.*, (Testudo scorpioides, *Lin.*) Cin. shavianum, *Bell*, (Cin. mexicanum, *LeC.*,) and Cin. longicaudatum, *Spix*, (including his brevicaudatum,) and perhaps a fourth, Cin. cruentatum, *Dum.* and *Bibr.*

one as the jaws shut. These edges are sharp in both jaws. Fish and Coleopterous insects were found in the intestines of two specimens examined immediately after their capture; the Fish in the one, and the insects in the other. The species of this genus have, to this day, been associated with the genuine Cinosternums of Central and South America; but the characters indicated above show them to differ generically.

I know three species of this genus, one of which has long been known under the name of Testudo pennsylvanica; the others were first described by Wagler, Gray, Duméril and Bibron, and Major LeConte, under the names of Cin. hirtipes, *Wagl.*,[1] Cin. oblongum, *Gray*,[2] Cin. Doubledayii, *Gray*,[2] Cin. leucostomum, *Dum.* and *Bibr.*,[3] Cin. integrum, *LeC.*,[4] and Cin. sonoriense, *LeC.*;[5] but these species are by no means all distinct.

THYROSTERNUM PENNSYLVANICUM, *Ag.*[6] The young are represented Pl. 4, fig. 7–12, and Pl. 5, fig. 16 and 17; and the eggs, Pl. 7, fig. 1–6, under the name of Cinosternum pennsylvanicum. Cinosternum oblongum *Gray* is only a male, and not a distinct species. Dr. Nott has sent me a specimen with a double row of median scales along the back. This is the only instance of an anomaly I have seen in the scales of any Cinosternoid. The geographical range of this species is very extensive. It occurs from Pennsylvania to Florida, and westward to the Mississippi valley. I am obliged to Dr. Nott for specimens from Pensacola and Mobile, and for others to Mr. Albert Stein, from the last locality. Dr. Benedict and Mr. T. C. Copes have sent me large numbers from the neighborhood of New Orleans.

THYROSTERNUM SONORIENSE, *Ag.* The young are represented Pl. 5, fig. 8–11, under the name of Cinosternum sonoriense, *LeC.* This species has thus far only been found in Mexico, but so near upon the borders of the United States that it deserves to be noticed here. Tucson, in Sonora, is the locality whence Dr. J. LeConte obtained the specimen described by his father.[5] Others from the same locality, and from Guadalupe Cañon, also in Sonora, are in the possession of the Smithsonian Institution.

[1] Syst. Amph., p. 137, tab. 5, fig. 29 and 30; Descr. et Icones, pl. 30.

[2] Cat. Brit. Mus., p. 33.

[3] Arch. Mus., 1852, vol. 6, p. 239, pl. 17.

[4] Proc. Acad. Nat. Sc., Phil. 1854, p. 183.

[5] Ibid. p. 184.

[6] This is the Cinosternum pennsylvanicum of modern authors, (comp. Dum. and Bibr., Erp. gén., vol. 2, p. 367, and Holbrook, N. Am. Herp. p. 307,) called also Terrapene pennsylvanica, Cistudo pennsylvanica, Emys pennsylvanica, and Testudo subrufa. I have not the slightest doubt that the Testudo tricarinata, *Retz*, in Schöpff's Hist. Test., (Daudin's Testudo Retzii,) which is generally referred to Cinosternum scorpioides on account of the dorsal keels, is the young of this same species. A comparison of my figures (pl. 4, fig. 7–9) with Schöpff's pl. 2, fig. 1–3 will satisfy the most skeptical. Schöpff's figures represent a specimen two years old; mine were recently hatched.

THYROSTERNUM INTEGRUM, *Ag.* LeConte's Cinosternum integrum from Mexico (Proc. Acad. Nat. Sc. Phil., 1854, p. 183). This species resembles Wagler's Cinosternum hirtipes, which belongs also to this genus. Wagler's species is founded upon a single male, preserved in the Museum of Munich, LeConte's upon a single female in his possession. I have examined both. The rough scales in the knee joint of the hind legs of Th. hirtipes are a sexual character, found in all the male Cinosternoids, and do not by any means constitute a specific distinction. The difference in the outline of the front margin of the carapace and the absence of an odd marginal scale in Cinosternum hirtipes may prove specific, though a tendency to such differences is already noticeable among the males and females of Th. pennsylvanicum. I have not seen Cin. Doubledayii, *Gray;* but I doubt its specific difference from C. pennsylvanicum, as well as its Californian origin. Nor have I seen Cin. leucostomum, *Dum.* and *Bibr.*; but I have often noticed specimens of Cin. pennsylvanicum with a white jaw, especially among the females, and Duméril and Bibron's species is founded upon a female.

III. PLATYTHYRA, *Ag.* The jaws are very weak; the mouth is broad and short. The head is long and low; it is regularly arched, back of the eyes; its sides curve slightly between the eyes and ears; its roof is very narrow between the eyes, and, as the mouth below is broad, the eye-orbits are carried far outward at their lower edges, and therefore open upward as well as forward and sidewise. The skull does not rise back of the orbits; indeed, the orbits project above it at their upper edges. The nose is short, much shorter than in Cinosternum; its outer surface curves all round it, so that, when the fleshy parts are preserved, it is rounded and pointed; its bony roof does not project forward as far as the jaw projects under it. The outer surface of the jaw slants inward under the eyes, curving out, above the alveolar edge, very little if at all; at the front end it slants backward faster than it slants inward at the sides, and the alveolar edge rises there; but just at the symphysis the jaw is brought down to a small, short point. The upper maxillaries are narrow from above downward, and weak. The vertical alveolar surface is not as high as in Thyrosternum; the horizontal alveolar surface is broad, but the bone under it is thin. The lower jaw is also weak, being very thin, especially about the symphysis, and not high, as in Thyrosternum. It is drawn out at the symphysis to a slender point. The alveolar surface is narrow all round; in front it is nearly vertical, and it flattens toward the angle, but near the angle the outer edge is raised somewhat more than in the other genera. The outer surface of the sides curves considerably outward for a short distance below the edge near the angle, and the jaws shut close. These jaws are clearly not fitted to tear any strong, fibrous substance; the only food found in the intestines of a specimen examined with that view was a mass of insects. The type of this genus is altogether new to science.

PLATYTHYRA FLAVESCENS, *Ag.* I have examined several specimens of this species, sent to me by the Smithsonian Institution. Some of them were obtained in Texas, near San Antonio, and upon the Lower Rio Grande; others on the Red River, Arkansas; and others at Camp Yuma, on the Gila River, by Dr. R. O. Abbott. It is of a yellowish green color; the scales are imbricated, and edged with black. The young are represented Pl. 5, fig. 12–15.

SECTION VIII.

THE GENERA OF EMYDOIDÆ.

From want of sufficient materials, I cannot attempt to characterize all the genera of this numerous family, and shall have to limit myself to the North American types. Fortunately these are numerous enough to enable me to show upon what features the genera are founded; even though I do not intend to enter here into such minute details of their characteristics as I have presented for the genera of the preceding families,[1] excepting where this becomes necessary to establish the validity of the new genera which I have recognized. The Chelydroids and Cinosternoids being excluded from the Emydoids, this family appears here circumscribed within narrower limits than those assigned to it by previous writers. All its American representatives are included by most modern herpetologists in two genera, Emys and Cistudo,[2] to which J. E. Gray has added the genus Malaclemys, and two sub-genera, Chrysemys and Lutremys.[3] They all lay oblong eggs, and the young when hatched are circular in outline in all of them;[4] but, even at that time, they vary in various ways in different genera and sub-families. The differences between the males and females are not so constant as in some other families. It is, however, generally the case that the males are flatter and more elongated. It will not be possible to determine accurately the period of the first appearance of this family in past geological ages, until the

[1] My object, in this second part of my work, is chiefly to show in what manner the principles advocated in the first part may be applied in illustrating any special group of animals. Having done this in the preceding sections as far as I am prepared to do it now, it would be superfluous to extend farther this analysis of the Testudinata. Moreover, the genera of Emydoidæ are too numerous to allow this to be done satisfactorily, without enlarging too much the bulk of this volume. As to the species, I have limited myself to mere hints, because I intend to give elsewhere full descriptions with figures of the new ones.

[2] Compare p. 251 and 252.

[3] Cat. Brit. Mus., 1844, p. 27, 28, 31.

[4] See p. 292 and 386.

remains of this order have been compared anew to ascertain which are genuine Emydoids, and which Hydraspides. The modifications noticed in the form have suggested their subdivision into several tribes or sub-families. (Compare p. 355.)

GENERA OF THE SUB-FAMILY OF NECTEMYDOIDÆ.

I. PTYCHEMYS, *Ag.* Horizontal alveolar surface of the upper as well as the lower jaw very broad, and divided by a ridge, the crest of which is tuberculate, and parallel to the cutting edge of the jaws. This edge is either smooth or serrate. The front of the alveolar margin of the upper jaw is either emarginated or more or less deeply notched, with or without a projecting tooth on either side (Pl. 27, fig. 5). Lower jaw very flat, with a hook or sharp point in front, behind which a keel extends along the symphysis, on each side of which there is a deep pit; alveolar surface spreading inward beyond the vertical branches of the jaw. Horny sheath of the lower jaw rough externally. A row of large scales, in the shape of a fold, along the outer edge of the forefeet (Pl. 27, fig. 1–3). Tessellation of the epidermis, amounting to scales upon the neck, but not upon the loose skin between the legs. The clawless fifth toe of the hind foot forms an angular projection on the posterior edge of the foot (Pl. 27, fig. 1–3). The color varies greatly with age, and even in different specimens of the same age. When young, the whole surface has more or less confluent ocellated and crescent or lozenge-shaped figures, which become more transverse afterwards, and may be resolved into simple blotches in old age. The claws also vary greatly in length and strength; sometimes, especially in half grown specimens, those of the three middle toes exceed the length of the whole foot. In the young, the median row of scales forms a blunt keel along the back, which fades entirely in the adult. The scales are at first smooth, or rather finely granulated; afterwards radiating rugosities appear upon their periphery, while in old age[1] they are longitudinally rugose.

PTYCHEMYS RUGOSA, *Ag.*[2] Its most prominent specific character consists in the

[1] This shows how unsatisfactory specific characters must be which are derived from the direction, or even the presence, of these rugosities.

[2] This species is well known to the American naturalists, under the name of Emys rubriventris, (Holbrook, N. Amer. Herp., vol. 1. p. 55, pl. 6.) first applied to it by Major LeConte; but, as this able observer has himself acknowledged, (Proc. Ac. Nat. Sc. Phil., 1854, p. 189,) it had been described before, by Shaw, as Testudo rugosa. Merrem and Schlegel consider it as a variety of Emys serrata, while Say and Harlan have actually confounded it with Emys serrata, from which it differs, even generically. Gray also describes it as Emys serrata, (Emys irrigata, *Bell*). Emys rivulata, *Gray*, is not specifically distinct. Duméril and Bibron describe it under three

more elongated form of the adult, the greater plainness of the color of the back, the strong, coarse serratures of the upper and lower jaw, and the prominent hooks on both sides of the median notch of the upper jaw. The geographical range of this species is very limited; it extends only from New Jersey to Virginia. I have received a large number of specimens of all ages from Washington, through the kindness of Professor Baird. A series of them are represented on Pl. 26 and 27, with the view of showing what is the range of variations in some species of this family. These plates tell their own story. The yellow, hieroglyphic ocelli and curved lines extending upon a gray ground over the whole surface of the shield (Pl. 26, fig. 1–4) gradually pass (fig. 5) into a system of more parallel lines, (fig. 6, 9, 10, and 11,) transverse upon the costal scales, (fig. 6 and 10,) more longitudinal upon the median scales, (fig. 9 and 11,) and ocellated upon the marginal scales, and the yellow bands deepen gradually to orange, (fig. 9 and 10,) the ground being more greenish (fig. 6) or deeper brown (fig. 5); or the lineated appearance vanishes entirely, and the surface becomes mottled (fig. 7). The sternum is at first yellow, with black blotches (fig. 4); but gradually becomes reddish, (fig. 8,) and even deep red, without a spot. In the adult, the mottled appearance of the shield prevails, and only faint traces of the transverse bands remain, (Pl. 27, fig. 1,) the general color being either gray mottled with red, or deep red mottled with black. Occasionally the whole surface is dark, and only slightly mottled or faintly banded with brownish red. It would have taken two or three more plates to represent all the variations of color I have observed.[1] I have only seen immature eggs of this species.

PTYCHEMYS CONCINNA, *Ag.*[2] This species occurs from the southern parts of North Carolina, through all the southern States as far as western Louisiana, and up the Mississippi valley as far as Arkansas. I have received a large number of specimens, through the kindness of Dr. W. B. Daniell, from Savannah; of N. A. Pratt, Jr., from Roswell, Georgia; of Dr. R. W. Jeffries, from Pensacola, Florida; of Dr. Holbrook, and Dr. Nott, from Mobile; of Professor Chilton, from New Orleans; of Mr. W. Sargent, from Natchez; of Professor Wailes, and Dr. L. Harper, from other

different names, as Emys rugosa, Emys irrigata, and Emys rubriventris (Erp. génér., vol. 2, p. 284, 276, and 281).

[1] This shows plainly that there are genera among our Emydoids in which neither the tint nor the pattern of coloration affords any specific characters.

[2] Few species of American Emyds have been more extensively mistaken than this. It was first described, in 1820, by Major LeConte, as Testudo concinna (Emys concinna, *Dum.* and *Bibr.*; Holbr. N. Am. Herp., vol. i., p. 119, pl. 19); but at the same time he gave another name, Testudo floridana, (Emys floridana, *Harl.*; Holbr. N. Am. Herp., vol. i., p. 65, pl. 8,) to large specimens observed by him in Florida. Besides adopting these two species, Gray described it also under the name of Emys ornata, and the young under that of Emys annulifera. Cat. Brit. Mus., p. 22 and 27.

localities in Mississippi; of Mr. G. Stolley, from Arkansas and Texas. Professor Baird has sent specimens to me, collected by Dr. Hoy in south-western Missouri, and others from Tarboro', North Carolina. It is considered everywhere at the South as the most delicious kind of Terrapene. The young are represented Pl. 1, fig. 13, and Pl. 2, fig. 4–6;[1] the eggs (Pl. 7a, fig. 20–23) vary much more in size and form than those of any other species in the family. This is also the case with the adults, which, as far as the form is concerned, vary much more than Ptychemys rugosa, though the range of variations in the colors is less. Some are very elongated, and narrower in front and behind than across the middle;[2] others are broad, and evenly rounded at both ends.[3] Some are flat; others very high, especially behind the shoulders;[4] and some have a very blunt head, while in others the snout is more prominent. Before I knew that the blunt form of the head was an embryonic feature which is sometimes preserved to advanced age, I had distinguished such specimens under the name of Ptychemys Hoyi. The most prominent character of the species consists in the comparative smoothness of the upper jaw, and the slight emargination of its edge, which is rather arched than notched; the lower jaw, however, is distinctly serrated, though less evenly than in Ptychemys rugosa and mobiliensis, and provided with a smaller and less prominent hook.

PTYCHEMYS MOBILIENSIS, *Ag.*[5] It is easily distinguished from the other species of the genus by the great height of the anterior part of the back, and still more by the serrature of both jaws; the lower, however, is more strongly and more coarsely serrated than the upper, which is deeply notched in the centre, with a prominent tooth on each side; there is a marked hook in the lower jaw. Its geographical range is believed to be rather limited. It is said not to be found west of Mobile Bay, where it is common, and to abound in Pensacola. I owe all the specimens I have from these localities to Drs. Nott and Holbrook; but others were sent to me from New Orleans by Professor Chilton, and from Guadalupe Mountains, Pecos River, Texas, and New Leon, near Cadercita, Mexico, by the Smithsonian Institution, so that this species extends much further west than is generally supposed. There can be no doubt upon the point, as, besides the specimens sent to me by the Smithsonian Institution, I have received young specimens, collected in Texas, by Mr. G. Stolley. The young are represented Pl. 3, fig. 14–16; the eggs (Pl. 7a, fig. 24 and 25) are larger and less variable than those of Ptychemys concinna.

[1] This is Gray's Emys annulifera.

[2] This is the Testudo (Emys) concinna, *Le C.*

[3] This is the Emys ornata of Bell.

[4] This is the Testudo (Emys) floridana, *Le C.*

[5] First described by Dr. Holbrook as Emys mobiliensis, vol. 1, p. 71, pl. 9.

PTYCHEMYS HIEROGLYPHICA, *Ag.*[1] Only known from the middle Western and Southern States. I have seen neither the young nor the eggs. I owe my specimens to the kindness of Dr. Gessner, of Columbus, Georgia. Dr. Holbrook describes it from Tennessee. The upper jaw is emarginated, but smooth; the lower jaw is thinner and more feeble than in other species, and its edge also smooth. The inner rows of tubercles in both jaws are more continuous. The whole body is very flat, and the hind margin more deeply serrated than in the other species.

PTYCHEMYS DECUSSATA, *Ag.*[2] This species is not found within the borders of the United States. It is a native of Cuba. But, as I had an opportunity of comparing specimens forwarded to the Smithsonian Institution by Professor Poey of Havana, I avail myself of this opportunity to state that it is a distinct species of the genus Ptychemys, more nearly allied to Ptychemys concinna than to any other.

II. TRACHEMYS, *Ag.* The chief difference between Trachemys and Ptychemys consists in the horizontal alveolar surfaces of the jaws, which are much narrower in Trachemys than in Ptychemys. The ridge of the upper jaw is less prominent, low in front, and not tuberculated; the lower jaw does not spread horizontally, and has only a slight, smooth inner ridge. There is a notch in the front of the upper jaw, but no lateral teeth; the lower jaw is arched upwards, and terminates in a hook. The marginal scales are separated by notches, and the edges of the scales again are themselves notched. The tessellation of the skin amounts to scales upon the neck, and upon the loose skin between the legs and the shield; but the form of the feet is the same as in Ptychemys. The young have a slight, obtuse median keel, and their scales are finely granulated. Their color is very characteristic; there are numerous longitudinal bands upon the median scales, and transverse ones upon the costal scales, while the marginal scales are ornamented with crescent shaped figures. As the animal grows, the bands become less and less numerous, or disappear completely in old age. At first smooth, they afterwards assume radiating ridges, up to the seventh or eighth year; and, finally, longitudinal ridges and rugosities prevail upon the scales. (Compare p. 431, note 1.)

TRACHEMYS SCABRA, *Ag.*[3] This species extends from North Carolina to Geor-

[1] First described by Dr. Holbrook, N. Am. Herp. p. 111, pl. 17. In the figure of Dr. Holbrook, the smallness of the head is somewhat exaggerated.

[2] This is the Emys decussata of Bell, figured by Ramon de la Sagra, Cuba, Rept., pl. 1.

Emys Berardi, *Dum.* and *Bibr.*, seems also to belong to this genus, judging from the description and the figures of the jaws published by A. Duméril, Arch. Mus. vol. 6, p. 231, pl. 15.

[3] This species is generally known under the name of Emys serrata (Holbr. N. Am. Herp., vol. 1, p. 49, pl. 5). It is also described as Testudo scripta, *Schn.*, Emys scripta, *Schw.* But, since it is undoubtedly the Testudo scabra of Linnæus, I have restored its oldest

gia.[1] I have received specimens from Wilmington, North Carolina, through Mr. S. T. Abert; and from Savannah, Georgia, through Dr. W. B. Daniell. I am, however, indebted for the largest numbers to Dr. Holbrook. Professor Baird has also sent me many young from Savannah. The young are represented Pl. 2, fig. 13–15. I have never been able to obtain its eggs. It is easily distinguished by its broad outline and great height; keeled along the back, coarsely tuberculated and rugose all over the shield, and deeply notched behind. There is a broad, transverse, light-yellow band across the neck, behind the eye.

TRACHEMYS TROOSTII, *Ag.*[2] In the Western States, from Missouri and Illinois to Tennessee and Louisiana. All the specimens I have seen were sent to me by Mr. G. Stolley, from the Osage River, Missouri; by Dr. Watson, from Quincy, Illinois; and by Professor Wailes, from Washington, Mississippi. Dr. Holbrook mentions it from Tennessee. It represents, in the valley of the Mississippi, the Trachemys scabra of the southern Atlantic States, and differs from it by its more elongated and flattened form, the absence of a median keel, the less coarse tubercles and rugosities of the shield, the less marked notches of the hind margin, the dark, mottled neck, and the total absence of longitudinal and transverse bands upon the neck. I have seen neither the young nor the eggs.

TRACHEMYS ELEGANS, *Ag.*[3] This species is easily recognized by its smoothness and flatness, and the bright blood-red longitudinal band which extends on each side of the neck. It is not as broad as Trachemys scabra. Its geographical distribution is very remarkable. It is found from the Upper Missouri to Texas; but it does not extend to the eastward beyond the lower course of the Ohio. I have received specimens from the Osage River and from Texas, through Mr. G. Stolley; from Burlington, Iowa, through Dr. J. Rauch; from Quincy, Illinois, through Dr. Watson; from Mississippi and Louisiana, through Mr. W. Sargent, Professor Wailes, and Dr. Benedict; and from the Yellow Stone, one of the head waters of the Missouri, from the neighborhood of San Antonio, from Matamoras, from the Brazos,

name. This circumstance removes a part of the confusion introduced in the synonymy of our Turtles, in the application of the name of serrata to different species. Testudo serrata, *Pen.*, is Chelydra serpentina; Testudo (Emys) serrata, *Say* and *Gray*, is Ptychemys rugosa; Testudo serrata, *Daud.*, is Trachemys scabra; Testudo scabra, *Shaw*, is Emys trijuga, *Schw.*

[1] Duméril erroneously quotes New York among the localities where it occurs. Emys vittata, *Gr.*, does not differ specifically.

[2] The first and only complete description is that of Dr. Holbrook, N. Am. Herp., vol. 1, p. 123, pl. 20. Temminck and Schlegel have confounded it with the preceding species.

[3] First described by Prince Max. von Neu-Wied as Emys elegans (Reise Nord-Amer., vol. 1, p. 213). Dr. Holbrook has described and figured it under the name of Emys cumberlandensis, N. Am. Herp., p. 115, pl. 18. Gray gives it the name of Emys Holbrookii, in the Cat. Brit. Mus., 1844, p 23. Professor Wailes mentions it, in his Geol. Rep., under the name of Emys Terrapin.

and from Brownsville, in Texas, through the Smithsonian Institution. There can be no doubt, therefore, that this species extends over the most extraordinary range; which is more difficult to explain than that of any American Emyd. The young are represented Pl. 3, fig. 9–11; the eggs, Pl. 7a, fig. 18 and 19.

TRACHEMYS RUGOSA, *Ag.*[1] I mention this species only to state that it differs from its North American representatives by its elongated form, the slight notches of the hind margin, and the very coarse rugosities of the back. There is a light longitudinal band on the side of the neck. Its color varies from a light salmon to a dark gray. I have seen specimens from the Havana, sent by Professor Poey to the Smithsonian Institution.

III. GRAPTEMYS, *Ag.* The great width of the smooth and flat horizontal alveolar surface, and the spoon shaped dilatation of the extremity of the lower jaw, chiefly distinguish this genus. There is no notch in the upper jaw. The tessellation of the skin amounts to scales only on the back of the neck; but there are large scales upon the feet, and a row of prominent ones along the outer edge of the fore legs. The young are strongly keeled, and their margin deeply notched, especially behind and on the sides, with a smooth surface, as prevails also in the adults; in old specimens, the concentric lines of growth of the scales are sometimes distinct. The persistence of the keel along the middle line of the back in the adults seems to be a character of inferiority, considering that it disappears in many species which are keeled when young, as, for instance, in Ptychemys. Though I had no opportunity of comparing specimens of Gray's Emys sinensis, I consider it as the Chinese representative of this genus. May not Emys Bennettii, *Gr.*, also belong to this group?

GRAPTEMYS GEOGRAPHICA, *Ag.*[2] Common from Pennsylvania and New York to Michigan, Tennessee, and Arkansas. I am indebted for specimens from Michigan to Prof. A. Winchell, of Ann-Arbor; from Quincy, Illinois, to Dr. Watson; from Delphi, Indiana, to Mr. Franklin Hill; from Ohio, to Mr. George Clark, of Toledo, to Mr. Joseph Clark, of Cincinnati, and to Dr. Kirkland, of Rockport; from Pennsylvania, to Prof. Baird, and S. S. Haldeman; from Blount county, Tennessee, to Prof. Baird; and from Arkansas, to Mr. G. Stolley. The young are represented Pl. 2, fig. 7–9; the eggs Pl. 7a, fig. 28–30.

GRAPTEMYS LESUEURII, *Ag.*[3] This species is only known in the Western States,

[1] This is the Emys rugosa of Gray, but not of Shaw. It is figured by Ramon de la Sagra, Cuba, Rept., pl. 2. Gray's E. vermiculata (Cat. Brit. Mus., 1844, p. 25) is the same.

[2] First described by LeSueur under the name of Testudo geographica. Dr. Holbrook called it Emys macrocephala, in the first edition of the N. Am. Herp. In the second he adopted LeSueur's name (p. 87). Emys labyrinthica *LeS.* is only a variety of this species, remarkable for the numerous meandering lines upon the bridges of the sternum.

[3] This species is commonly called Emys pseudo-

where it ranges from Michigan, Wisconsin, and Iowa, to Louisiana. I have received specimens from Burlington, Iowa, through Dr. J. Rauch; from Marion County, Missouri, through the Smithsonian Institution; from the Osage River, through Mr. G. Stolley; from Maumee River, Ohio, through Mr. Geo. Clark; from Arkansas, through Mr. G. Stolley, and the Smithsonian Institution. Judging from the many specimens sent me by Mr. W. Sargent and Professor Wailes, it must be common about Natchez. The young are represented Pl. 2, fig. 10–12; the eggs Pl. 7a, fig. 31–34. The eggs vary more in form than those of Graptemys geographica, as the animal itself also does.

IV. MALACOCLEMMYS, *Gray*.[1] A very distinct genus, first noticed by J. E. Gray, who refers only one species to it, though I believe that his E. Bealii is the Chinese representative of ours. There are no scales on either side of the neck, the upper arms, the thighs, or the loose skin of the legs, but merely a tessellation of the epidermis; distinct scales only upon the legs, arms, and feet. Inguinal or axillary scales small or wanting. Head long and peaked, or blunt, short, and rounded.[2] Horny sheath of jaws straight, strong, and smooth; horizontal alveolar surface flat and broad, without ridges; alveolar edges meeting at an angle in the upper jaw, and tapering to a triangle in the lower. Young keeled, adults tuberculated, upon the middle line. The median scales remain longer broad than in any other Emydoid, indicating a lower standing, which agrees with its mode of life in salt-marshes.

MALACOCLEMMYS PALUSTRIS, *Ag.*[3] Common along the Atlantic coast, in salt-marshes, from New York to Texas, and even to South America. Specimens from the States bordering on the Gulf of Mexico are generally smaller than those of the Atlantic States, and have the edge of the carapace more turned up;[4] but such specimens occur even in the vicinity of New York. This species varies most remarkably in its color and sculpture, as well as in the size of the head. The lighter varieties are plain greenish gray, the darkest almost black; there are those with concentric stripes upon the scales, alternately dark and light colored; some are entirely smooth, and others have deep concentric grooves, indicating the successive lines of growth of the scales. The sternum varies from light yellow or yellow-

geographica: but the specific name LeSueurii is older. It is evident from his reference that Gray at first applied the name of Emys LeSueurii to this species, and not to Gr. geographica; now Gray calls it also Emys pseudo-geographica. Prof. Wailes enumerates it in his Geol. Report under the name of Emys serrata.

[1] Though Gray spells this name Malaclemys, I have altered it to suit its etymology.

[2] There is not another genus the head of which varies as much in size and form as this.

[3] Malaclemys concentrica, *Gray*, Cat. Brit. Mus. 1844, p. 28. It is the Testudo terrapin, *Schoepff*, Emys terrapin, *Holbr.*, Test. centrata, *Daud.*, Test. concentrica, *Shaw*, Test. palustris, *Gmel.* and *LeC.*

[4] This is probably the Emys areolata, *A. Dum.* Arch. Mus., vol. 6, p. 223, Pl. 14.

ish green to reddish brown, plain, or dotted or striped concentrically. I am indebted to Prof. Baird for a large series of specimens from the Middle States; Dr. Nott has sent me others from the Gulf States. Dr. Holbrook's figure (Pl. 12) represents a broad-headed variety; DeKay's, (Zoölogy of New York, Pl. 3, fig. 5,) one with a pointed head.[1] The young are represented Pl. 1, fig. 10–12; the eggs, Pl. 7a, fig. 11–14.

V. CHRYSEMYS, *Gray*. Although J. E. Gray considers these Turtles only as a sub-genus of Emys, I am satisfied that they belong to a distinct genus, the representatives of which are closely allied to the other Nectemyds, and not to the Clemmyds, as Wagler supposed. The large web of their feet and the broad horizontal alveolar surface of the upper jaw show this distinctly, even though the horny sheath that covers its edge be narrow. They die in a few days when kept out of the water, while the Clemmyds are much more terrestrial, and may be kept for months on dry ground during the hottest days of the summer. This is the case, at least, with Glyptemys insculpta. The most prominent generic character consists in a notch in front of the horny sheath of the upper jaw, on each side of which the edge of the sheath projects more or less to form lateral teeth, that are close together. The young are not keeled[2] at all, and are flatter than those of the other genera. The colors are very constant, and afford good specific characters.[3]

CHRYSEMYS PICTA, *Gray*.[4] This species may be at once distinguished from the other species of the same genus by the form of the middle row of scales upon the back, and the manner in which the costal scales[5] of the carapace meet those of the vertebral row, and also by a broad, yellow band, limited by a black line, which extends along their anterior margin. The ground color is dark, grayish brown; the margin has intensely blood-red blotches. The scales of the median row have their lateral angle higher up, and the upper margin of the lateral scales nearly on a line with the upper margin of the median scales, while in all the other species the median scales are more regularly hexagonal, and the

[1] J. E. Gray's Emys macrocephalus, Cat. Brit. Mus. 1844, p. 26, is a large-headed variety of this species.

[2] The absence of a keel in the young, and the small size of the adult, seem to indicate that this genus stands highest in its sub-family.

[3] The only variations that I have noticed correspond to the changes which take place with age; there is, though very rarely, some difference in the extent of the lyriform figure upon the sternum.

[4] This is the well-known Emys picta of most modern herpetologists, the Testudo picta of Hermann and Schneider; Testudo cinerea, *Brown*, Emys cinerea, *Schw.*, is the young. Seba already mentions it as Testudo ex Nova Hispania. It also appears as Terrapene picta in Prince Canino's works. Wagler calls it Clemmys picta.

[5] Occasional anomalies are observed in the form of the scales. Prof. S. S. Haldeman has sent me one specimen in which one of the costal scales and the posterior median scales of the back are divided; and another in which there is one additional costal scale.

upper margin of the lateral scales is on a line with the lateral angle of the median scales. This is already visible in the youngest specimens, at the time of hatching. (Comp. Pl. 1, fig. 4 and 5 with fig. 6; also Pl. 3, fig. 1; Pl. 5, fig. 2; and Pl. 6, fig. 8; compare also p. 293, note). The sternum is golden yellow; occasionally, but very rarely, with a partial lyriform figure; now and then also a streak or a dot may be seen upon the costal scales. But the form of the scales shows this species to differ strikingly from the others. The eggs are represented Pl. 7a, fig. 1–3. Chrysemys picta is described as occurring everywhere in the United States; but this is incorrect. It occurs only in the Eastern and Middle States as far as the northern boundary of South Carolina, whence it extends to the north-western parts of Georgia. Its northern-most boundary is New Brunswick, according to Mr. M. H. Perley. I have obtained specimens from North Carolina, through Mr. W. C. Kerr, and from western Georgia, through Mr. Al. Gerhardt. I have never observed it in the Southern States, nor further west than the western parts of Pennsylvania and New York, and the eastern parts of Ohio. In western Ohio, in Indiana, Wisconsin, and Michigan, it is replaced by *Chrysemys marginata;* in Missouri, and parts of Illinois, by *Chrysemys Bellii;* in Minesota, by *Chrysemys oregonensis;* and in Louisiana and Mississippi, by *Chrysemys dorsalis.*

Chrysemys marginata, *Ag.* It is flatter, broader, and more rounded than Chrysemys picta; the bands between the scales of the carapace are either yellow or blood-red, narrower than in Ch. picta, but bordered with more distinct black lines. Their lateral margins exhibit parallel ridges, while in Chrysemys picta they are perfectly even. The ground color is bronze green, with a few red or yellow spots. Upon the sternum there is a black lyriform blotch, as in Chrysemys Bellii, but narrow and plain, and not mottled (see Pl. 5, fig. 3). This figure is, however, occasionally wanting. The young are represented Pl. 1, fig. 6, and Pl. 5, fig. 1–4; the eggs (Pl. 7a, fig. 4–6) are larger than in Ch. picta, though the animals are of the same size. I am indebted for specimens of this species to Dr. P. R. Hoy, of Racine, Wisconsin; to Mr. J. A. Lapham, of Milwaukee, Wisconsin; to Dr. Manly Miles, of Flint, Michigan; to Professor Alex. Winchell, of Ann-Arbor, Michigan; to Mr. Franklin Hill, of Delphi, Indiana; and to Dr. Rauch, of Burlington, Iowa. One specimen was sent to me from Rome, in the State of New York; but I cannot ascertain by whom, nor whether it had been found in that State.

Chrysemys Bellii, *Gray.*[1] By its form, this species resembles more Chrysemys picta than Chrysemys marginata; but the scales of the carapace are arranged as

[1] Synops. Rept. in Griffith's An. Kingd., 1831, p. 31, under the name of Emys Bellii. The generic name Chrysemys is first introduced in the Cat. Brit. Mus. 1844, p. 27, where Mr. Gray states that this species is named *Emys speciosa* by Clift in the Cat. Mus. Coll. Surg. No. 1525.

in the latter, while the margin of the costal scales is smooth. There are a few irregular yellow or red bands across the costal scales, with a few red dots. The ground color is copper-red, or bronze colored. The lyriform black blotch of the sternum has lateral angular projections. I have received many specimens from the Osage River, in Missouri, through Mr. G. Stolley. Dr. George Engelmann has also sent me many from St. Louis; and I have found it myself in western Illinois. The young are represented Pl. 6, fig. 8 and 9.

CHRYSEMYS OREGONENSIS, *Ag.*[1] Mr. Nuttall, who discovered this species, states that it was found in Oregon; Prince Max von Neu-Wied observed it near Fort Union, on the Upper Missouri. I have received specimens from the Smithsonian Institution, collected near Fort Snelling, Minesota, in the Yellow Stone River, Nebraska, and among the Guadalupe Mountains, in Texas. My friend James M. Barnard has brought me a living specimen from White Bear Lake, Minesota, which agrees exactly with Dr. Holbrook's original specimen, now in the Museum of the Academy of Natural Sciences, in Philadelphia. The back has numerous yellow lines upon a greenish ground, and the sternum regular blotches in the form of a lyre all over its surface. The young represented (Pl. 3, fig. 1–3) belongs to the Smithsonian Institution.

CHRYSEMYS DORSALIS, *Ag.* I have seen only a few specimens of this species, the only one of the genus which I have not kept alive for a considerable time. They were sent to me by Prof. Wailes, who collected them in the States of Mississippi and Louisiana.[2] Lake Concordia is the locality whence most specimens were obtained. The Smithsonian Institution possesses specimens from the same source. This is the broadest and shortest species of the genus. It is easily distinguished by the great width of the median scales of the carapace; their form resembles more that of the scales of the young Ch. picta than that of the adults of other species. Margin of the costal scales plicated, as in Ch. marginata. As in Ch. picta, the sternum is uniformly golden yellow. The yellow median stripe along the back is broader than in any other species. The marginal scales are not so highly ornamented as in other species. Indeed, the characteristic, crescent-shaped figures of the margin occur only upon the lower surface, and are quite pale.

[1] This is Harlan's Emys oregonensis (Am. Journ. Sc., vol. 31, p. 382, pl. 31, and Holbrook's N. Am. Herp. vol. 1, p. 107, pl. 16). I have great doubts respecting the accuracy of the statement of Nuttall, that this species was found in Oregon. It has never been seen in that territory by the many expeditions which have explored it since Nuttall; nor did Dr. Pickering notice it when there with the United States Exploring Expedition. I am therefore inclined to believe that he made some mistake in reference to its origin.

[2] I suppose that the specimens carried from New Orleans to Paris by Mr. Trécul, and referred to Emys picta by Duméril, belong to this species. I have never seen Ch. picta anywhere in the States bordering on the Gulf of Mexico. Prof. Wailes also quotes this species as Emys picta in his Geol. Rep.

SUB-FAMILY OF THE DEIROCHELYOIDÆ.

This sub-family embraces only a single genus, as far as I know, and to this day that genus numbers a single species, the North American Emys reticulata, *Schweig.*[1] In many respects it recalls the Australian Chelodinæ, by the unusual length of its neck; but differs strikingly from them by the mode of articulation of its neck vertebræ. It is a genuine Cryptodeira, and in no way allied to the Pleurodeiræ.[2]

DEIROCHELYS, *Ag.* The upper jaw is notched in front; the lower jaw is low, arched upwards, and terminates in a sharp point.

DEIROCHELYS RETICULATA, *Ag.* The geographical range of this species is much more extensive than is generally supposed. It is found in all the Southern States, from the southern parts of North Carolina to Louisiana, though it seems to be nowhere very common. I have obtained specimens from North Carolina, through Mr. S. Th. Abert and Dr. C. L. Hunter; from South Carolina, through Dr. Holbrook; from Pensacola, through Dr. R. W. Jeffries; from Mobile, through Dr. Nott; and from Red River, Louisiana, through Professor Baird. The young are represented Pl. I., fig. 14–16, and Pl. II., fig. 1–3; and the eggs, Pl. VII., fig. 17–19.

GENERA OF THE SUB-FAMILY OF EVEMYDOIDÆ.

EMYS, *Brongn.*[3] All modern herpetologists, with the exception of Dr. Holbrook and Maj. LeConte, have confounded the North American representative of this genus with the common Box Turtle,[4] Cistudo virginea, with which it is only remotely allied. The distinguishing character of the genus consists in the narrow, horizontal alveolar surface, and the narrow, horny sheath of the bill, which is notched in front, the alveolar edge rising gradually to form a triangular emargination, while under the eye it is arched down. No part of the plastron is sutured to the carapace; the median pair of bones are united to it by unossified, flexible derm; the plastron itself is hinged at the middle transverse suture, and the two movable plates, thus hinged upon one another, are raised to the

[1] Compare Holb. N. Amer. Herp. p. 59, pl. 7. It is the Testudo reticulata, *Bosc.*; Terrapene reticulata, *Bonap.*

[2] Compare p. 335, note, and 351.

[3] Gray has proposed the name Lutremys for this genus; but the older name, Emys, must be preserved. He has further subdivided the Cistudos, with which he associates the genus Lutremys, into Cistudo proper and Cyclemys.

[4] Dum. and Bibr. Erp. gén. vol. 2, p. 210; Gray. Cat.. Brit. Mus. p. 30. Comp. also my remarks, p. 249 and 252.

carapace when the animal withdraws into the shield for protection. (Compare the Cinosternoids, p. 348.) In Cistudo the beak projects downward. The head is long and wide, its front part spreading apart downward, so that the eyes open upward, and the mouth is broad; while in Cistudo the head is high, the sides of its front part nearly vertical, and the mouth narrow. The lower jaw is low, and arched upward to a point in front, its alveolar surface being almost vertical.

EMYS MELEAGRIS, *Ag.*[1] The young are nearly circular, and entirely black above, without a spot, and the scales granular; the sternum is also black, with a white edge. They are represented Pl. 4, fig. 20–22; and the eggs, Pl. 7a, fig. 26 and 27. As they grow larger, they elongate rapidly; indeed, this species is comparatively longer than its European representative, the Emys lutaria. This is truly Shaw's Testudo Meleagris, notwithstanding Shaw's own recantation. The young might be confounded with the figure of Emys pulchella, *Schöpff*, which is the young of the European species. This species extends through the Northern States, from New England to Wisconsin. It has been found in Massachusetts, near Lancaster. by Dr. W. I. Burnett and Mr. S. Tenney, and in Concord by Mr. D. H. Thoreau. I have specimens from Michigan, sent to me from Ann-Arbor by Professor Al. Winchell and by Dr. A. Sager, and from Flint by Dr. Manly Miles, and from Wisconsin by Dr. Hoy, of Racine.

GENERA OF THE SUB-FAMILY OF CLEMMYDOIDÆ.

It was Wagler who first showed that there are several genera included in the old genus Emys, even after removing the genera now referred to the families of Cinosternoids and Chelydroids. Among these genera there is one, Clemmys, which constitutes a distinct sub-family,[2] embracing still several distinct genera, four of which are characteristic of the Faunæ of North America.

I. NANEMYS, *Ag.* Edge of upper jaw straight, slightly notched in front; lower jaw slightly arched upward;[3] snout rounded, and its sides not compressed laterally; neck and loose skin between the legs scaly. Large scales upon the legs and feet.

NANEMYS GUTTATA, *Ag.*[4] The young are represented Pl. 1, fig. 7–9; the eggs.

[1] Major LeConte was the first to notice that the North American Cistudo Blandingii is synonymous with Shaw's Testudo Meleagris; but he calls it Lutremys Meleagris.

[2] Comp. p. 356.

[3] The upper jaw may occasionally have a deeper notch in front, and the sides of the notch may be tooth-like; but the bill never projects downward as in Calemys.

[4] This is the well-known Emys guttata of modern herpetologists. The best figure is that of Dr. Holbrook's, N. Am. Herp., pl. 11. It is also known

Pl. 7a, fig. 7–10. Its yellow dots upon a black ground are very characteristic. When hatched, there is but a single dot upon each scale of the shield, and none upon the marginal scales; as it advances in age new dots appear, one by one, upon each scale, until they become very irregular, and extend to the margin of the shield. I have, however, seen old specimens that were entirely black, and others in which the dots remained few and regular. The sternum varies from black to yellow, with black blotches, especially upon the centres of the scales. This species is common in New England, and in the middle Atlantic States. It does not extend south of North Carolina, nor west of New York and Pennsylvania. I have received large numbers from North Carolina, through the kindness of Professor Baird, but never noticed it in the South or in the West.

II. CALEMYS, *Ag.* This genus differs from Nanemys in having a deep notch in front of the upper jaw, with a large tooth on each side, projecting in the shape of an arched bill. Sides of the head compressed, but not narrowing downward. The lower jaw is strongly arched upward.[1]

CALEMYS MÜHLENBERGII, *Ag.*[2] I have never seen the young, or the mature eggs of this species, which seems rather rare, and entirely limited to New Jersey and the eastern parts of Pennsylvania. Its scales are either perfectly smooth or concentrically grooved; with or without keel along the back. The dark orange blotch on each side of the neck, extending over the temporal muscles, is characteristic of this species.

III. GLYPTEMYS, *Ag.* The upper jaw projects in the form of a bill, arched downward, notched at the tip, and so compressed sidewise that the margin of the mouth is narrower than the top of the forehead over the nose. The edge of the lower jaw is straight, except the tip, which is greatly arched upward. The horny sheath of the horizontal alveolar surface is narrow in both jaws. The margin of the shield is very thin and spreading in the young, and the surface of the scales is coarsely granular. In the adult they have radiating ridges, which in very old age are sometimes entirely smoothed down.

GLYPTEMYS INSCULPTA, *Ag.*[3] This species is common in the North-eastern States, and is found only as far south as New Jersey. I am indebted to Mr. S. Tenney for hundreds of specimens from Lancaster, Massachusetts. He has also secured

under the names of Emys punctata and Clemmys punctata.

[1] As I have not seen the young, I am somewhat doubtful respecting the value of the differences pointed out between this genus and the preceding.

[2] This species is well represented by Dr. Holbrook, in his N. A. Herp. pl. 4, under the name of Emys Mühlenbergii.

[3] This is the Emys insculpta of Major LeConte. Duméril and Bibron have erroneously identified it with Schoepff's Testudo pulchella, which is the young of the European Emys lutaria. Emys speciosa, *Bell*, is the smooth variety of the old age.

a specimen for me from the Little Madawaska River, in lat. 47° north, Maine. There is less difference in the length of the tail in the males and females than in Actinemys marmorata.

IV. ACTINEMYS, *Ag.* Edge of the upper jaw straight, with a notch in front; lower jaw broad at the symphysis toward the lower edge, strong, and strongly arched upward. Males, with a long, tapering tail; in the females the tail is short and blunt. Young, with radiating striæ upon the scales, the centre of which remains for a long time granular, as in Testudo tabulata. Adults, smooth.

ACTINEMYS MARMORATA, *Ag.*[1] Varies from green to black, mottled with light dots, more or less radiating. Light yellowish below; a few specimens have the black angle of the sternal scales that characterizes Glyptemys insculpta.

This is the only species of Emydoid known from the western slope of the continent of North America. I have received a fine series of specimens from San Francisco, California, from my friend, T. G. Cary, Jr. I have also examined a number of specimens belonging to the Smithsonian Institute, among which are the originals of Baird and Girard's Emys marmorata, and of Dr. Hallowell's Emys nigra. The former species is founded upon the young, the latter upon the black variety of the adult. It appears from these specimens that Actinemys marmorata is found from Puget Sound to Monterey, California.

Three out of five genera of this sub-family are characteristic of New England and the middle Atlantic States, while the fourth is exclusively found in California, and the fifth in Europe. There are no representatives of this type in the Western or Southern States. This is particularly remarkable, when considered in connection with the similarity which exists between the ichthyology of Europe and that of New England, and the striking contrast there is between that of the latter region and the other ichthyological Faunæ of North America.

THE SUB-FAMILY OF CISTUDININA.

I have already stated, (p. 251,) that the genus Cistudo should be limited to the North American Box Turtles, and that it differs widely from the true genus Emys, with which it is generally associated.

CISTUDO, *Flem.* Head, very high. The temporal arch is either cartilaginous or only partially ossified. Horizontal alveolar edge, narrow; beak of the upper jaw projecting downward, with or without a notch in the middle; lower jaw, sharp-

[1] This is Baird and Girard's Emys marmorata, Proc. Ac. Nat. Sc. Phil. 1852, p. 177, described also under the name of Emys nigra, by Dr. Hallowell, Proc. Ac. Nat. Sc. Phil. 1854, p. 91.

pointed in front. Hind foot, plantigrade. The plastron is attached and hinged essentially as in Emys. It is probable that the difference between the manner in which the plastron is moved in the Cinosternoidæ and in the Emydoidæ with movable sternum depends on family characters, and that a single hinge could not exist in the Cinosternoidæ, nor a double one in the Emydoid.

Though I have examined many hundred specimens of this genus, I do not yet feel justified in expressing a decided opinion respecting the value of the differences which I have noticed among them, as they were mostly adults. The differences noticed may indicate different species; but they may also mark only varieties. There is, however, a remarkable circumstance connected with the specimens that came under my observation: their variations are limited to particular regions of the country. A satisfactory investigation of this genus would therefore involve the whole question of local and climatic varieties.

CISTUDO VIRGINEA, *Ag.*[1] The north-eastern type of the genus has the most extensive range. It is found in New England, and westward as far as Michigan, and southward as far as the Carolinas. I have received three-toed specimens from North Carolina, through Mr. W. C. Kerr, which agreed in every other respect with those of New England. The young are represented Pl. 4, fig. 17–19; the eggs, Pl. 7, fig. 10–14.

CISTUDO TRIUNGUIS, *Ag.*[2] The western and south-western type is remarkable for having, almost universally, only three toes to the hind feet. Specimens from Louisiana and Mississippi are particularly small, and of a pale yellowish color, with a few spots. The eggs are represented Pl. 7, fig. 15 and 16. I have received a very large number of specimens from Dr. Benedict and Mr. T. C. Copes, of New Orleans, all of which agree in their small size and pale color. Had I not noticed a few larger specimens from the Osage River and from Georgia, I should not hesitate to consider them as a distinct species.

CISTUDO ORNATA, *Ag.*[3] The north-western type is round, broad, and flat, without keel, even when young, (Pl. III., fig. 12 and 13,) while the young of Cistudo virginea are always strongly keeled. I have received specimens from the Upper Missouri through the Smithsonian Institution, and from Iowa through Dr. J. Rauch.

CISTUDO MAJOR, *Ag.* The southern and south-eastern type grows to a very large size, and is more oblong than the others. I have received specimens from Mobile through Dr. Nott, and from Florida through Mr. Fr. W. Putnam.

[1] This is the Cistudo carolina of most authors, Grew's Testudo virginea. Gray's Emys kinosternoides is the young.

[2] Gray has described a three-toed Cistudo from Mexico as a distinct genus, under the name of Onychotria Mexicana. Proc. Zool. Soc. of London, 1849. The outer toe of the hind foot fades away so gradually that the genus Onychotria cannot stand.

[3] Of all the Cistudo which I have seen, this is most likely to be a distinct species.

SECTION IX.

GENERA OF TESTUDININA.

Were it not for the circumstance that Linnæus has united all Testudinata into one genus, I believe the classification of this order would long ago have been more natural than it is now. To this day only eight genera have been referred to the family of Testudinina, though its species are very diversified, and exhibit, no doubt, characters indicating generic differences beyond those acknowledged at present, if I may judge from the few that have come under my inspection. The name of Testudo must of course be preserved for that genus to which the common European T. græca belongs. Wagler has already separated from it the T. marginata under the name of Chersus, and Fitzinger has applied the name of Chelonoidis to Testudo tabulata, that of Geochelone to T. stellata, that of Psammobates to T. geometrica, and that of Megalochelys to T. indica; while Gray has retained the name Chersina for T. angulata, and Duméril and Bibron have established the genus Homopus, not to allude to the genera Pyxis and Cinixys of Bell. Although I believe most of these genera to be well founded, I cannot refer to either of them the two species which I have observed in North America.

XEROBATES, *Ag.* Differs from all other Testudinina in having the front legs compressed, without a sign of a plantigrade palm, and large, flat nails; the hind feet are plantigrade, with a round surface. There are only a few large scales side by side upon the forehead. The head is very broad across the temporal muscles; the region of the eyes, nose, and mouth is short; and the top of the skull nearly horizontal between the eyes. The mouth spreads out widely immediately behind the symphysis. The lower jaw is high, and spreads apart from above downward. The inner edge of the horizontal alveolar surface of the upper jaw descends to a sharp ridge all around; from it another ridge reaches across the surface at the symphysis to the vertical surface. The ridge which fits into the furrow of the lower jaw is very prominent and sharp; it is interrupted at the front end only for a short distance. The inner edge of the alveolar surface of the lower jaw rises no higher at its front than at its hind end, but is nearly horizontal, and nowhere as high as the outer alveolar edge; the ridge thus formed is interrupted for only a very short distance at the front end. In the horny sheath of the alveolar edge and the inner ridge at the symphysis there is a notch, which fits over the opposite ridge of the upper jaw. The oblong, rounded plastron is curved upward at the ends.

XEROBATES CAROLINUS, *Ag.*[1] This species extends from South Carolina, through all the Southern States as far as Texas, in the southern parts of which it is replaced by the next species. Its eggs are represented Pl. 7, fig. 28 and 20. I am indebted to Dr. Th. S. Savage for interesting observations upon the habits of this species. "The domicile of the Gopher consists of an excavation, of a size at the mouth just sufficient to admit the animal, and runs in an oblique direction to the depth of about four feet. From the entrance it enlarges and expands to a considerable extent, resembling in its interior outline a vessel of globular shape. Being concealed, it is sometimes a dangerous cavity to horsemen at full speed. It is inhabited but by one pair. When the dew is on the grass, or it has rained, the animal emerges in search of food, which it seems to require daily. It feeds on grass and succulent vegetables of various kinds. They eat also the gums that exude from trees, especially the inspissated sap of the pine, as seen often at the lower part of the stem and exposed roots of that tree. This they will eat also in a state of confinement. Their eggs are not laid in their domicile, but in a separate cavity near its mouth. The habit of the animal in oviposition, it is said, is to draw a circle on the ground about four inches in diameter, and to excavate within this to a depth of about the same number of inches, expanding as it proceeds, in a manner similar to that adopted in making its domicile. In this are deposited five white eggs, of a round form. The number being complete, the cavity is filled with earth and pressed down smoothly, and to a level with the surface, by the weight of the animal. The time in hatching is said to be between three and four weeks. The month in which they lay is June. They are long-lived, and attain the size of fourteen to eighteen inches across the carapace. To capture the Gopher, a deep hole is dug at the mouth of their domicile, into which they fall as they emerge for food."

XEROBATES BERLANDIERI, *Ag.* The young is represented Pl. 3, fig. 17–19. It has a small yellow dot in the centre of the median and costal scales; the marginal scales are only edged with yellow. The sternum is narrower and more projecting in front than that of X. carolinus; in the adult it is even forked. Behind it is broader and more turned downward. The centre of the scales remains granular for a longer time. The gland of the lower jaw is larger and more prominent. This species is smaller than the preceding, and limited to southern Texas and Mexico. All the specimens that I have seen were forwarded to me for examination by the Smithsonian Institution. They were collected by the late Mr. Berlandier, a zealous French naturalist, to whom we are indebted for much of what we know of the natural history of northern Mexico.

[1] This is the Testudo carolina of Linnæus, Testudo Polyphemus of Daudin.

Whenever a type of the present period exhibits characteristic features connected with a circumscribed geographical distribution, it is an interesting problem to ascertain whether the fossil representatives of past ages found in the same region belong to the same type or not. The existence of North American fossil Testudinina during the Tertiary period having been ascertained by Dr. Leidy from the beautiful specimens found in Nebraska, I became very anxious to compare them with the living Xerobates, which are the only North American Testudinina. Professor James Hall, whose collection of fossils, from the Mauvaises Terres, exceeds all expectations, has provided me with ample means to make this comparison, and I have satisfied myself that they do differ not only from Xerobates, but even from all living Testudinina, in combining characters which at present exist only in Emydoids with those that are strictly characteristic of Testudinina.

For the sake of comparison, I add a few remarks upon the other genera which I have been able to examine.

CHELONOIDIS, *Fitz.* The head is narrower across the temporal muscles, and the region of the eyes, nose, and mouth longer, than in Xerobates; the top of the skull between the eyes descends further forward in this genus. The lower jaw is not as high as in Xerobates, but is more rounded at the symphysis, and spreads less backward; moreover, it does not here spread apart from above downward, but curves out for a little distance below the upper edge, and then turns in to the lower edge. The alveolar surface of the upper jaw is raised under the nose to a large, round, inverted pit, and has no ridge at the symphysis, but a small one on each side of the pit. The ridge around the inner edge of this surface, and the one parallel to it, are both small; the latter is tuberculated. The inner edge of the alveolar surface of the lower jaw rises higher toward the front end, so as to be, for some distance, as high or higher than the outer alveolar edge; this inner ridge is interrupted by a broad depression where the alveolar surface rises steeper to fit into the pit above. To this genus belongs the Testudo tabulata, *Auct.*, of which I have been able to examine a number of living specimens, sent to me from Surinam by Mr. C. J. Hering. A close comparison with living specimens of Xerobates carolinus shows them to be entirely different, even generically, although Schlegel considers them as identical.[1]

MEGALOCHELYS, *Fitz.* This type is closely allied to Chelonoidis; but I have examined too few specimens to be able to determine whether it is a distinct genus or not. There are some characters which seem to indicate that it is distinct; for example, the inner furrow along the alveolar surface of the upper jaw continues deep to its front end, whereas in Chelonoidis it vanishes forward; the

[1] Temm. and Schl. Fauna japon. p. 70.

ridge on the same surface which fits into the furrow of the lower jaw is sharper and more prominent than in Chelonoidis, and is not tuberculated. To this genus belongs the large Galapago Turtle, Testudo indica, a living specimen of which was sent to me by Mr. Patrick H. Frey, of New York.

The genera above described may be readily distinguished from Testudo græca, which is the type of the genus TESTUDO proper. In the latter, the outer furrow of the alveolar surface of the upper jaw passes round the front end without interruption, and with little change in width; the ridge which fits into the furrow of the lower jaw is very short, being interrupted by a long space in front; the inner edge of this surface descends only for a short distance from the hind end forward. In the alveolar surface of the lower jaw the furrow and inner ridge are very short, and the long, steep surface in front of them turns around the end with a broad curve. CHERSUS, *Wagl.*, is at once distinguished by the movability of the posterior lobe of the sternum, but differs also in the scales of the legs. It is founded on Testudo marginata. PSAMMOBATES, *Fitz.*, is well characterized by the small scales which uniformly cover the four plantigrade feet. To it belong the well-known Testudo radiata.

SECTION X.

CHELONIAN FAUNÆ OF NORTH AMERICA.

The more minutely the geographical distribution of animals is investigated, the more do regularity and order appear to exist among them in this respect; so much so, that I strongly entertain the hope that naturalists may one day read the design which has presided over this arrangement. Owing to the extensive contributions I have received for my investigations from every quarter of the country, and particularly from the collections of the Smithsonian Institution, which contain specimens from the least explored parts of the continent, I have been able to trace the natural boundaries of all our Testudinata with a much greater degree of accuracy than has hitherto been done. The long lists of localities from which I have seen specimens of the different species enumerated in the preceding sections, and the names of the observers to whom I am indebted for them, will, I trust, afford a satisfactory guarantee for the accuracy of the generalizations derived from their study.

The most striking result of these comparisons is the certainty thus acquired, that, while certain genera and species have a very wide range, others are circumscribed within as narrow limits as any other type of animals. It has already been stated, (p. 301,) that there is a great difference between the geographical distribution of the Sea Turtles and that of the fluviatile and terrestrial species of this order. There are, in fact, only two marine Faunæ of Testudinata, — that of the Atlantic Ocean, and that of the Pacific, including the Indian Ocean; and between the two there exist only specific differences between their representatives, the genera are the same. In the Atlantic Faunæ we have four species along the American coasts: Sphargis coriacea, Thalassochelys Caouana, Chelonia Mydas, and Eretmochelys imbricata; while in the Pacific Fauna only one species, the Chelonia virgata, has thus far been noticed along the western coast of America.

Among the fresh-water species there are two, Chelydra serpentina and Ozotheca odorata, which extend nearly over the whole range occupied by Testudinata, east of the Rocky Mountains. Thyrosternum pennsylvanicum is also very widely distributed; and so is Malacoclemmys palustris; but this last occurs only in salt-marshes along the sea-shores from New York to Central America. All the other species have a more or less circumscribed home; so that the whole country may be divided into a number of very natural Chelonian Faunæ, according to their distribution.

1st. *The North-eastern Fauna.* It extends as far north and east as Turtles occur, that is, through parts of Nova Scotia, New Brunswick, and Canada West, a little beyond the forty-fifth isotherm. Westward it reaches Lake Erie, and southward North Carolina, extending along the Alleghanies even as far south as Georgia. Its boundaries coincide with those of Chrysemys picta. It is chiefly characterized by Clemmydoidæ, three distinct genera of which occur within its area: Nanemys guttata, which, like Ch. picta, ranges through its whole extent, with the exception only of its most north-eastern parts; Glyptemys insculpta, which is found from the most northern to the middle regions of the Fauna; and Calemys Mühlenbergii, which occurs only in the middle region. Ptychemys rugosa is characteristic of the borders of the Chesapeake Bay. Cistudo virginea is found everywhere, but sparingly in the northern range; while it extends very far westward and southward, where it is most common. Chelydra serpentina and Ozotheca odorata also occur everywhere, while Thyrosternum pennsylvanicum begins to appear in its middle tracts only. Along the sea-shores, Malacoclemmys palustris begins also in the middle region of the Fauna; but it is nowhere found in the interior, far from salt water. Emys Meleagris, which is characteristic of the north-western Fauna, is rare here, and so also is Graptemys geographica. On the western borders of this Fauna, Aspidonectes spinifer begins to make its appearance; but there is no trace anywhere of the family of Testudinina.

2d. *The Western Fauna.* This Fauna extends westward from the western parts of Pennsylvania to the arid plains at the foot of the eastern slope of the Rocky

EMBRYOLOGY OF THE TURTLE.

CHAPTER FIRST.

DEVELOPMENT OF THE EGG, FROM ITS FIRST APPEARANCE TO THE FORMATION OF THE EMBRYO.

SECTION I.

THE ORIGIN OF THE EGG.

On account of the hitherto unknown peculiarities which the earlier stages of growth of the Turtle's egg exhibit, it is necessary to say a few words in reference to the caution which was taken to make sure that these strange features are perfectly normal. A young animal was resorted to, on account of the greater abundance of the smallest sized eggs, and also because the ovary is less opaque, than in the adult. Those of the latter age were nevertheless consulted also, for comparison, and in them it was ascertained that the process of growth is the same as with the younger animals.

In order not to distort the eggs by pressure, tearing, or pulling, the ovary was cut out entire by severing its peduncular attachment, thus avoiding the necessity of touching the eggs. To prevent drying, and also that it might be kept in a natural medium, the ovary was laid in the serum taken from the cavity of the body, and brought under the microscope in a watch-glass. If, however, the serum is left uncovered for a longer time, it evaporates and changes its

Mountains, beyond which Turtles do not occur. Its northern limit is as high as the junction of the Yellowstone and the Missouri, but does not touch the shores of Lake Superior. Its southern limits extend to Tennessee, Arkansas, and Kansas. The most characteristic species of this Fauna are Amyda mutica, Aspidonectes spinifer and nuchalis, Chrysemys marginata, Bellii and Nuttalii (oregonensis), Graptemys geographica and LeSueurii, Trachemys Troostii and elegans, and Emys Meleagris. Ch. marginata is limited to the region of the lakes; but Ch. Bellii extends to the junction of the Missouri and Mississippi, while Ch. Nuttalii extends to the Upper Missouri. Strange to say, Aspidonectes spinifer is among the species found furthest to the north; but Asp. nuchalis takes its place in Tennessee. Emys Meleagris is most common in the region of the great lakes. Cistudo virginea extends as far west as the great lakes, and is replaced by Cistudo ornata further west and north. Chelydra serpentina and Ozotheca odorata range as far west as any other Testudinata, though the latter does not extend so far in a north-westerly direction as Chelydra; this is also the case with Thyrosternum pennsylvanicum. Ozotheca tristycha and Ptychemys hieroglyphica occur in the more southern parts. There is something extraordinary in the distribution of Trachemys elegans, as it ranges from the upper Missouri to the lower Rio Grande, while Trachemys Troostii occupies only the middle and more southern parts of the western Fauna. Graptemys LeSueurii is also found in a north-southerly direction, while Gr. geographica extends from east to west in the more northern parts. The Testudinina are as completely foreign to this Fauna as to the north-eastern.

3d. *The Southern Fauna.* Its boundaries are easily traced. Beginning on the Atlantic coast in the southern parts of North Carolina, it extends through South Carolina, Georgia, Florida, Alabama, Mississippi, Arkansas, Louisiana, and northern Texas. These limits coincide with the range of Ptychemys concinna and of Deirochelys reticulata, and nearly also with that of Platypeltis ferox and Xerobates carolinus, only that the two latter do not extend to North Carolina; Platypeltis ferox does not even extend beyond Georgia. However, the most striking types of this Fauna are Xerobates carolinus and Gypochelys lacertina. Besides Platypeltis, another Trionychid, Aspidonectes asper, occurs in this latitude, but only in the more westerly part of the Fauna, within which Goniochelys triquetra and Chrysemys dorsalis are also limited; whilst Trachemys scabra is only found on the Atlantic side of Georgia and in the Carolinas. Ptychemys mobiliensis occurs only in the States bordering on the Gulf of Mexico. Ozotheca odorata and Thyrosternum pennsylvanicum belong also to the southern Fauna; and so does Chelydra serpentina, unless the southern Chelydra be a distinct species. (Comp. p. 417, note 2.) The same may be said of Cistudo virginea, unless C. triunguis and major are also distinct species. Malacoclemmys palustris is found everywhere along the sea-coast.

density, and in this condition acts upon the contents of the egg, causing great disturbances and a very false state of things. To avoid such an alteration, the serum must be changed often, and that held in reserve kept closely corked up, or, what is still safer, the animal resorted to for fresh supplies, if it has been opened carefully, so as not to allow the blood to become mixed with the fluid in requisition. With these precautions the whole ovary was surveyed under magnifying powers of from fifty to two hundred diameters, and the peculiar features of the eggs of all sizes noted, except those of the very minutest, which, on account of the short focus of the higher powers of the microscope necessarily used for their investigation, required to be observed in thinner portions of the organ carefully cut away.

In no case however was pressure, that great obstacle to all correct appreciation, applied, except to see what the effect might be, and also in certain experiments upon the consistency and elasticity of the contents of the egg. This is mentioned in particular, because the first glance reveals the fact that every egg in the ovary is more or less flattened, the oldest ones least, and those successively younger more and more, till the very minutest ones are reached, which again have the usual spherical form of simple cells. A peculiar brilliancy characterizes the surface of the ovary, which is owing to the circumstance that all the eggs, from nearly the smallest to those about one fiftieth of an inch in diameter, contain, on the side toward the surface of the ovary, a clear and more or less homogeneous fluid, underlaid by a darker and denser, yellowish, granular substance, facing the centre of the organ (Pl. 8, fig. 3–9). This peculiarity will be spoken of in detail, when describing the progressive stages of growth in the egg.

Now, knowing the features of the eggs of different sizes, when in an undisturbed state, portions of the ovary were carefully cut out, and the stroma dissected away in case of the presence of larger eggs, or thin spots examined for the smaller ones. Although, from their elasticity, eggs removed in this way assumed a natural shape and condition after instances of pressure or pulling with the point of the knife, yet such eggs were avoided in the examination of the contents, not knowing what effect might have been produced upon the ultimate structure of the yolk. This precaution in regard to the yolk was subsequently found to be in no small degree important, as reference to the plasticity and viscidity of the yolk cells will testify.[1] The stroma and the cells of the corpora graffiana are so exceedingly transparent that there is no difficulty in detecting the minutest eggs which may be imbedded therein (Pl. 8, fig. 1, o^1,

[1] Water has a far more injurious effect even than pressure, especially upon the yolk cells, and is most rigorously to be avoided in all cases. But more will be said upon this in detail hereafter.

4th. *The Mexican Fauna.* I have to mention this Fauna on account of its extension into the boundaries of the United States. Among its characteristic Testudinata found along the Rio Grande, the most remarkable are Xerobates Berlandieri and Aspidonectes Emoryi. Platythyra flavescens extends further north, even as far as Arkansas, while Thyrosternum sonoriense occurs further west, in Sonora. The Turtles of Cuba, as far as I know them, differ specifically from those of this and the preceding Fauna.

5th. *The Californian Fauna* has a wide range from north to south, beginning at the straits of Juan de Fuca and extending to the Gulf of California, and yet over this whole extent of country only a single Turtle is found, Actinemys marmorata; for it is not true, that the Galapago Turtle occurs also in California in a wild state; and the existence of a distinct species of Cinosternum on that side of our continent appears very doubtful to me. (Comp. p. 429.)

There is a very striking resemblance with what obtains in Europe in this scarcity of Testudinata in California, contrasted with their extraordinary diversity and great number on the eastern side of the continent. This, again, recalls their profusion in eastern Asia; so that, even with reference to the special geographical distribution of the Testudinata, the great laws that obtain with regard to the similarity and differences of the continents are fully confirmed.

After what has just been stated, it is hardly necessary to call especial attention to the fact, that, upon a map representing the geographical distribution of the Testudinata in North America, the whole table-land between the Sierra Nevada of California and the Rocky Mountains, as well as the eastern slope of the latter, down to the Great American Desert, would be left entirely blank, not a single species of Turtles extending over any part of this extensive tract of land. It would be a mistake, however, to infer, from this fact, that these animals are excluded from mountainous regions. In the range of the Alleghanies there are many species, which ascend to the height of several thousand feet, and among those that reach the greatest heights are Cistudo virginea, Chelydra serpentina, and a species of Aspidonectes, probably Asp. nuchalis (comp. p. 406); but I regret that I am unable to give the absolute height with any degree of accuracy.

k[1], 5, 9); yet the thinnest portions are preferable, because of the greater homogeneity of the transmitted light.

It is beyond the reach of pen or pencil to illustrate satisfactorily the unmistakable physiognomy of the ovarian egg at that age, when it is smaller than the cells of the Graffian body which surround it. The task becomes more difficult still when the very natural question arises, How is it known that these peculiar forms are eggs? The most direct answer to this question is, by comparison, which is in fact at the base of all inductive reasoning. But the argument here is not to be one of words alone; for every step of the induction shall be illustrated by examples drawn from nature, and words will serve merely to point out their true character.

No one will deny that the most correct and philosophical method is that which follows the development of the life of the eggs, seizing upon and watching the changes and growth of the minutest cells till that period when, by their contents and acknowledged characteristics, they are recognized without reserve to be eggs; although, in an argument upon the identity of an unknown with a known body, our finite senses usually prefer to start from the latter, and proceed toward the former by a series of reductions, tracing embryonic life just as it sometimes apparently develops itself in a series of retrograde metamorphoses. Yet, although we have in a few rare cases seeming examples of this kind, it is, to a mind so deeply imbued with the phenomena of the whole course of development as to follow instinctively in the path of nature, a forced and unnatural mode of interpretation of the phases peculiar to the several successive stages of the genesis of the ovarian egg.

Upon submitting the ovary to the microscope, with a magnifying power of about five hundred diameters, there may be observed in the field, scattered among the larger eggs, quite a number of smaller ones, varying from mere granular, minute, dark specks (Pl. 8, fig. 1, *a*) to a size about four times the diameter of the cells of the corpus graffianum which inclose them (Pl. 8, fig. 1, *b–p*). These eggs have all one common physiognomy, which at once impels a belief that they are so many different grades in the development of one kind of cells, peculiar in themselves, and very different from the mass of hyaline and colorless cells of unvarying size about them. The thick, dark outline, the peculiarly brilliant and strongly refractive, homogeneous yellowish contents, and the lateral nucleus,[1] when present, are entirely different from the thin walls, transparent, irrefractive contents, and central nucleus of the neighboring cells of the corpus graffianum (Pl. 8, fig.

[1] The conflicting views entertained by anatomists upon the formation of cells have rendered some changes necessary in the nomenclature of the cell, its envelope and contents, which are discussed below.

1, o^1, h^1). Therefore, since by tracing a series of peculiar cells, from the minutest granular forms to those of a larger size, which have the readily acknowledged characteristics of an egg, there can be no doubt left, that the former are, by nature, the same as the latter, we may proceed to describe the several phases of development in all these bodies, as the progressive steps in the growth of the egg.

The initial form of an egg is a dark, oily looking, granule-like, spherical body, (Pl. 8, fig. 1, *a*,) situated among the interstices[1] of the cells of the corpus graffianum. As the latter not only, but even their nuclei, surpass such an egg in size by several diameters, it is superfluous to debate the question, whether the egg may not be the nucleus of a cell of the generating organ.[2]

At this period in the life of an egg, there arises the question, not only of its origin, but also of that of independent cells; for the former is only one of the many variously endowed vesicles by which the animal economy performs its multitudinous functions. Nay, in fact, it is more: the egg, the animal of one single cell, potentially contains the principle of the future phenomena of life; so that the genesis of an egg is neither more nor less than the genesis of one kind of cells, containing within themselves the type of all future cell formations. The granule-like egg, which we have mentioned as the youngest, is a homogeneous mass, from the centre to the surface; the thick outline being not indicative of a wall, but resulting from the strong refraction, which has no such definite internal boundary as obtains in all membranes around limited contents. But yet it must be acknowledged that the superficial particles are determinedly the cell wall, and indeed may have a coherence among each other greater than those situated interiorly, yet not of sufficient density to produce a refraction so different from the latter as to be recognizable by the microscope. There is a warrant for this probability, in known examples on a larger scale; the yolk parent or outer cell,—even when it has reached maturity, (Pl. 9, fig. 11i, *a;* and Pl. 9a, figs. 36–40, *a*,) and contains a large nucleus and several nucleoli, —shows this plainly, for it is a mass of excessively hyaline granules, the outer of which are only a little more coherent to each other than those within, but not dense enough to produce a recognizable refraction till water is applied and the contents burst out; whilst the wall, (Pl. 9, fig. 7c, and Pl. 9a, fig. 7a,) by its greater

[1] The first blood corpuscles are yolk-cell nuclei which have undergone changes identical with those of the whole "embryo," and they alone remain free, circulating in the channels hollowed out in a mass of cells identical with themselves. These are the first cells originating interstitially, but yet, after all, not essentially so, as is the case with the egg; for each blood corpuscle is a segment of an original yolk-cell nucleus, which has gone through the process of self-division; whilst the egg originates just as the primary yolk cell does, by conglomeration of particles, and the formation of a membrane around the parietes of this concretion.

[2] See Thompson's suggestion to that effect in Cyclopædia of Anatomy, article Ovum, p. 136, Oct., 1856.

tenacity, holds together for a while longer, but finally disintegrates and discloses its mode of origin in the immense number of minute, faint granules, identical in appearance with the extruded ones, which are dancing about in zigzag. At times a granular structure, giving to the wall the appearance of a cellular membrane on a very minute scale,[1] may be detected, even before it has lost its consistency.

As the egg grows larger, the dark outline decreases in thickness, and the contents become less oily and more transparent, till at last, when it is about $\frac{1}{8000}$ of an inch in diameter, a well defined wall discloses itself under the guise of a thin pellicle (Pl. 8, fig. 1, *f*, *g*).

The study of a series of eggs,[2] such as have just been presented,—in which at first no wall is visible, then faint indications of a superficial change appear, in which a gradual differentiation of the parietal from the more internal substance ensues, and the finally well established separation of the two is unmistakable, the latter, the internal, inclosed by the former, which presents itself as a sharply pronounced, extremely tenuous envelope,—leaves no doubt that the egg-cell wall has an origin totally external to all that which is inclosed in it at the time it becomes visible. Whether this wall has arisen by a gradual change in the density of the superficial particles, or by original deposition in its present form, it is impossible to determine; but this much is demonstrated, that at least a small portion of the egg elements exists before its wall has become established, and that this wall, far from being the nidus in which its contents are developed, is more probably the offspring of what it incloses. It would be more proper, perhaps, and nearer the true nature of the operation, to say that the yolk membrane arises synchronically with the concretion of the original yolk particles, as a denser exterior stratum, which, subsequently becoming

[1] Indeed, it is no exaggeration to say, that such is essentially a cellular membrane; for as cells originally are what we have designated as granules, and cells unite to compose a membrane, why may not granules, cells, combine to make a wall around a certain substance? In some respects it is only a matter of size, after all; put on the higher powers of the microscope, and the granules may appear so large that they would be called cells by every observer; and what are minute cells under three hundred diameters, are, to the eye, mere granules with thirty or forty diameters.

[2] In order to preserve the natural relations which exist between the many isolated figures drawn to illustrate the structure of the eggs of different stages of development, it has been necessary to adopt a very peculiar mode of numbering and lettering the figures. Yet, as it is not possible to describe at once all the different features which these figures are intended to bring before the eye, it may facilitate the understanding of the following pages, if the reader will first make himself familiar with the arrangement of the Plates 8, 9, and 9a, by studying the explanation which accompanies them. The student already familiar with Embryology may also read with advantage, Section 5 of this Chapter, before any other.

In the quotations, the reader ought to mark carefully the difference between the letters following the figures without comma, which indicate the whole figure, and those following a comma and are referred to in italics, which designate the individual illustrations belonging to the same objects.

still more differentiated, stands out as a tenacious layer, capable of holding in durance the internal, fluid, mobile portion of the conglomeration.

Anterior to this, in some cases, (Pl. 8, fig. 1, *c*, c^1,) but not always, a nucleus, the germinal vesicle, makes its appearance. There is, however, no relation between the size of the egg and the period of the first appearance of the germinal vesicle; at one time we find it nearly filling a small egg (fig. 1, *c*, c^1); at another, it is not at all present in a comparatively large one (Pl. 8, fig. 1, *f*, *i*, *k*). Beyond a certain size, (Pl. 8, fig. 1, *l*,) however, about $\frac{1}{3600}$ of an inch in diameter, it is never absent; so that there is a limit, on one side, to the irregularity of its development. It is hardly necessary, after what has been said, to remark, that the nucleus has no part whatever in the formation of the egg cell, but is entirely a subsequent feature of the contents among which it is introduced. True enough, there is a solid substance around which its cell wall arranges itself, just as most observers have of late advocated, but here the parallel ceases; for the basis of this operation is not the nucleus, the germinal vesicle, as they would have it, but the yolk, to all intents and purposes.[1] The nucleus, in this instance at least, is often a feature of very tardy appearance, and always arises like a swelling, having the concave contour of the egg-cell wall for a basis. It is always very transparent, but most especially so in the younger stages of the growth of the egg, (Pl. 8, fig. 1, *m*, *n*, *o*, *p*, fig. 3 and 3a,) when it is often difficult to determine its outline definitely, its transparency arising from the mode of its origin, of which we will speak presently.

The germinal vesicle is always visible to the naked eye, in eggs of from one sixteenth of an inch in diameter to full-grown ones; its presence is indicated by a clear, dark, round spot at the surface, where it originates, as will be shown below (Pl. 9, fig. 9 and 10; and Pl. 9a, fig. 32 ([2]) and 32a). It appears very often on the distal side of the egg, and at other times next to the attachment of the ovum,[3]

[1] Barry, (Phil. Trans., London, 1838, p. 308–310, pl. v., fig. 1, 18, and 19,) Leuckart, (Handwörterbuch der Physiologie, etc., von Dr. Rudolph Wagner, article Zeugung, p. 815,) and Thompson, (Cyclopedia of Anatomy, London, 1854, article Ovum, p. 76 and 77, fig. 53,) all hold to the origin of the yolk substance around the previously existing germinal vesicle; but if we mistake not, in many instances the germinal vesicles of these authors were the true eggs, and in others the vitelline sac was concealed by its close contact with the wall of the Graffian follicle.

[2] The small germinal vesicle of this magnified egg will be perceived on the left side of the figure, about one third from the centre.

[3] Various authors, who have made more or less special investigations upon this subject, assert that the germinal vesicle, throughout the animal kingdom, has a central position in the younger stages of the egg, but that later it approaches, and finally plants itself at the surface. Now, since we have pointed out its superficial position from the very beginning, in Testudinata, and have observed the same feature in the eggs of other animals, as future volumes will show, we have reason to believe that the assertion of these authors, respecting the situation of this vesicle, cannot be sustained by more rigid researches. Such a situation may be only apparent, owing to the position of the egg under the microscope.

so as to be completely hidden by the peduncle of the calyx. Originally this vesicle is a collection, in a globular form,— against the wall of the egg cell, (Pl. 8, fig. 1, *j*, *l*,) where it always remains,—of a less refractive, lighter, and more albuminous substance than the surrounding medium; yet, until the former has assumed a certain density, dissimilar from the latter, the refraction of the two is so nearly alike that we cannot perceive the difference, but soon there ensues a period when they are faintly distinguishable from each other, and at last every thing becomes clear and unmistakable. It is not, however, till a much later period that a well defined wall becomes apparent, even after the germinal dots, or, viewing the egg as a cell, the nucleoli of the egg cell, have developed themselves to a certain degree (Pl. 8, fig. 8a); yet we have strong presumptive evidence that a layer of more coherent substance is present at the surface, just as in the case of the yolk parent cells, and also in the case of the dots of the germinal vesicle belonging to a much larger egg, which will be described when speaking of the growth of this vesicle in detail. Again, when water is brought in contact with the vesicle, it swells slightly, and then bursts, just as if a membrane had suddenly given way; whereas, were the mass homogeneous throughout, it would fall to pieces gradually. If it is homogeneous from centre to superficies, why does it not spread and mix with the yolk, as happens after the sudden bursting consequent upon pressure? We can hardly want further evidence, except an actual view of the membrane, to feel satisfied that it is present, although in a less palpable form than it is usual to acknowledge as such.

So far we have followed the growth of the egg, as a whole, up to that point where it has gained all its characteristics, and thus disclosed the mode of its origin, and proved that, what was once a mere granule-like cell, is developed into that which is called an egg, and yet still remains a cell.[1] The further progress of the egg contents, namely, the yolk, the germinal vesicle, and its dots, is so complicated, that each part must be treated separately, in order to avoid confusion, and also to lay particular stress on every one, since the several components have a feature peculiar to each, and entirely different from any other.

[1] It is contended, by some investigators, that the egg cannot be looked upon in the light of a cell, because of its subsequent complication. True, it is not necessary to insist that it is identical, as a body, with the cells of animal tissues; it is nevertheless a cell, but a cell of peculiar derivation and destination, the simplicity of which, as well as its similarity to those among which it originates, is very early lost in the highly organized nature of its succeeding developments. Again, these authors, Thompson (loc. cit., p. 135) at least, advocate that the germinal vesicle being, as they erroneously hold, the primitive basis of the egg, is more probably the true egg cell, and the whole ovum a complex cell.

SECTION II.

DEVELOPMENT OF THE YOLK.

In order that the history of the yolk, which follows, may be complete in itself, it is advisable to revert to the first appearance of what is afterwards called yolk, as the original contents of those particular granule-like cells which eventually declare themselves as eggs.

We have already said, that at first the yolk is a perfectly homogeneous, highly refracting, brilliant, yellowish fluid, which gradually loses its density, and becomes more transparent and colorless up to a certain age of the egg, when the whole begins to appear heterogeneous in its aspect (Pl. 8, fig. 1, *p*). At this period, when the egg is about $\frac{1}{1000}$ of an inch in diameter, there ensues a great and very remarkable change; the contents of the egg divide into two very different looking portions, (Pl. 8, fig. 1, *p*,) one of which retains the character of the stage just passed, (upper part of fig. 1, *p*,) whilst the other, which is the larger, assumes a clear, hyaline, and hardly refractive condition, indicative of a greater amount of albumen than in the darker part.

The germinal vesicle is usually found in the more transparent portion of the egg, but now and then it lies in the darker region; when in the former it is at times difficult to recognize, because its density and that of the enveloping medium are so nearly alike as to give a very faint difference in refraction.

Soon after this, when the egg has reached the size of $\frac{1}{1000}$ of an inch in diameter, the homogeneous fluid of the darker side becomes spotted here and there with very minute granular vesicles, with dark outlines (Pl. 8, fig. 2, 3, 3a). These vesicles are mostly situated near the periphery of that side of the egg; but gradually they appear nearer and nearer to the centre, increasing in size at the same time, till they occupy the whole field adjoining the hyaline region, (Pl. 8, fig. 4, 5,) when the whole mass presents an opaque, dense, fuscous colored and coarsely granulated appearance. There is no constant relation, at any given time, between the size of the egg and the amount of light and dark parts, in definite proportions to each other. One egg may have its denser region but slightly granular, while that of another of the same size will be filled with granules. The same indefinite relation occurs throughout the different parts of the egg, even to quite an advanced period.

But, to return again to the younger stages, we would note the very remarkable and sharp, straight line of meeting of the two different portions of the egg, which, at a certain age, runs in a plane passing through one of its great circles (Pl. 8, fig. 3, and 3a). After carefully dissecting away the envelopes, the eggs can be rolled backward and forward, by tipping the watch-glass which holds them, or by blowing upon the serum in which they swim, so as to disturb its level; and as the several eggs pass by the eye, one is reminded of glass globes whirling along, freighted on one side with golden pebbles. The splendor of such an apparently trifling object needs to be seen to be appreciated. Now follows the encroachment of the granulated portion of the egg upon the clear space, at the time the egg has reached the size of about $\frac{1}{200}$ of an inch in diameter. This proceeds after various modes: sometimes the clear space fills up in a gradual way, as if a deposit was forming in it, (Pl. 8, fig. 6, 6a,) till the whole spherical cavity is occupied by a dense, equally distributed, coarsely granular mass; at other times a projection starts out from the darker part into the clear fluid, (Pl. 8, fig. 10,) and divides it into halves, each of which gradually darkens with deposits; again, the granules appear, as it were suddenly, in heaps, (Pl. 8, fig. 9, 9a, 13a, 15,) throughout the homogeneous medium, and, gradually extending their arms to each other, anastomoze, and inclose clear hyaline spaces, (Pl. 8, fig. 15,) the so-called oil drops[1] (Pl. 8, fig. 7, 16a, 16b); finally, a ring of coarser materials appears near the centre, giving the egg a zonated appearance, (Pl. 8, fig. 18a, 19,) with the germinal vesicle at times between the dark bands. This last phase is found in eggs of about one twentieth of an inch in diameter, which are easily seen with the naked eye; and we believe it to be peculiar to this age. In fact, the different features mentioned above correspond more or less to a certain stage of the development of the yolk cells. Beyond the last stage, just mentioned, we cannot trace this progressive growth step by step, on account of the opacity and size of the eggs; but thus far it is perfectly reliable that these diverse appearances are normal, since they were recognized, not in one only, but in as many eggs as were examined. By this time the egg has assumed a uniform bright yellow color on that side where the germinal vesicle shines through as a clear (Pl. 8, fig. 17, 17a) but dark spot, immediately surrounded by a very light yellow ring, which shades off into the deeper color beyond. As the egg progresses toward its full development, the yellow color of the yolk grows deeper, (Pl. 9, fig. 4, 5, 6, 7, 8,

[1] These clear spaces must not be confounded with those which are observed in the spheres of segmentation, though they originate probably in the same manner. That there are eggs containing oil drops, cannot be doubted; they are frequent in the eggs of Fishes, but they differ greatly from the albuminous clear spaces of the Turtle's eggs just described. Much more extensive investigations upon the structure of the eggs of animals of different classes, in their successive stages of development, are still required, before satisfactory comparisons can be instituted between them and the features peculiar to different types pointed out. Comparative Ovology is a branch of Embryology yet to be founded.

9,) the light ring around the germinal vesicle becomes still lighter, and the dark spot more sharply defined, until, when full-grown, (Pl. 9, fig. 10, and Pl. 9a, fig. 32, 32a,) the yolk is orange yellow, the ring around the germinal vesicle dead white, and the spot above it a neatly bounded circular area, (Pl. 9a, fig. 32a,) resembling a pinhole over a dark background.

It is important to notice, in this connection, that there is a marked difference in the gradation and relative size of the smaller eggs when compared to the larger ones. The innumerable minute eggs which are buried in the folds of the ovary exhibit, up to a certain size, every possible degree of development, from the smallest granule-like egg cells to characteristic eggs visible to the naked eye. There are immense numbers of these small eggs of every size, apparently in the same state of progress; and they seem all to form but one series, in which every successive stage is represented by an indefinite number of eggs. Not so with the larger eggs, from the time they exceed the size of a large pin's head up to their full maturity. These larger eggs appear always in regular sets of a definite number, and, what is particularly important, this number coincides with the number of eggs the different species of Turtles lay at one time. In Nanemys guttata, which lays two or three eggs, each set contains only two or three eggs; in Chrysemys picta, which lays from five to seven eggs, each set contains from five to seven eggs; and so with every species, even with those which, like Chelydra serpentina, lay more than thirty eggs. Four such sets can readily be distinguished in every ovary, one of which contains mature eggs (Pl. 9, fig. 10); another set contains eggs about half that size (Pl. 9, fig. 8); a third set contains still smaller eggs, (Pl. 9, fig. 5, 6,) the size of which stands in the same relation to the second set, as those of the second to the first; the fourth is smaller still, in the same ratio (Pl. 9, fig. 1, 2, 3). Below these it is difficult to distinguish the different sizes, and impossible to determine which are the eggs likely to start in advance of the others, after the largest set has been laid. But the uniformity of the eggs of each set, the conformity of their number with that of the eggs laid by different Turtles, and the absence of eggs of intermediate sizes between those of different sets, can leave no doubt, that, after a certain time, the eggs of each successive brood are determined in the ovary, and undergo a long development, equal in duration to four times the interval which intervenes between the successive periods of laying. As I have satisfactory evidence that our Turtles lay only once a year, it follows, therefore, that an egg requires four years, from the time there exists a marked difference among the eggs of different sizes, to acquire its full maturity; not to speak of the length of time required for its formation and earlier development. We shall have occasion hereafter to consider the importance of these facts, in connection with the act of fecundation of the eggs.

Having thus sketched beforehand, as it were, and described, the grosser changes in the yolk mass up to its maturity, we will now return to the starting point of this digression, and indicate the intimate structural changes which the yolk cells undergo successively, as these changes correspond to each successive feature of the growing egg.

At the time the granules begin to invade the clear space, (Pl. 8, fig. 6, 6a,) they are rather coarse and irregular in outline; but the next step beyond this (Pl. 8, fig. 8a) in the growth of the egg reveals a diminution in their size, as if they were, as is probable, redissolved by their mixture with the more albuminous fluid which has received them. Soon afterward, in an egg not much larger than the last, or even of the same size, they again appear very coarse, yet dark and irregular, and withal lighted up by seven or eight quite large, clear, albuminous globules, scattered irregularly in different parts of the mass (Pl. 8, fig. 7). These globules, as we have seen above, are the remains of the hyaline region of the younger egg. That they are not oil drops, such as have been described by various authors as occurring in certain stages of the growth of the egg, is easily demonstrated, first, by their very faint refraction, (Pl. 8, fig. 7, and 16a, 16b,) and most conclusively by their mode of origin, as already described. The slightest pressure diffuses them through the yolk mass, whilst oil globules are more tenacious, and if they break up, each fraction at once assumes a globular form.

Another slight advance, in eggs of about $\frac{1}{180}$ of an inch in diameter, again brings before us a finely granulated yolk, pretty evenly distributed throughout the egg. A still finer granulation, almost imperceptible, occurs throughout another egg which is hardly larger (Pl. 8, fig. 11a). The application of the extreme high powers of the microscope, however, shows that these granules are spheres of dark, oily globules (fig. 11a, *a*) closely packed together, which would be perfectly invisible under an amplification of four hundred diameters, and leave one to suppose that nothing but a homogeneous fluid occupied the field. Other eggs, (Pl. 8, fig. 9, 9a,) of the same size as the last, are far from resembling it: hardly one half of the yolk is dense and dark, and amid the finer materials, coarse angular grains arranged in heaps are scattered pretty freely, but as yet few grains appear in each heap; within the lighter space these grains are much less numerous, being only grouped in twos or threes, and even that not frequently. In this portion of the yolk are also very numerous minute but distinct particles, like dust floating in the air across a sunbeam. The clear globular spaces previously mentioned are defined by the anastomozing of these heaps, which form irregular, sponge-like meshes. A further approach of these heaps to each other is observed in more advanced stages of growth of the egg; but, before considering these changes, we must not pass over an intermediate condition of peculiar features, which has seldom been seen during our investigations.

In an egg of about $\frac{1}{800}$ of an inch in diameter, the whole central mass (Pl. 8, fig. 12, *f*) is coarsely granulated, whilst a layer of about one eighth the diameter of the egg, resting upon the yolk sac, consists of excessively minute molecular forms, densely packed together, (*e*,) resembling the entire contents of another egg of a somewhat smaller size, described above (Pl. 8, fig. 8a). The only explanation we can give of this appearance is, that it is one of the several modes by which the coarse granular yolk fills up the entire egg, as it resembles, in a certain respect, those phases where the concentric rings occur (Pl. 8, fig. 19).

Returning now to the consideration of the more closely related heaps of coarse, more or less angular granules, in an egg which may easily be recognized by the unaided eye, (Pl. 8, fig. 13a,) we find that, closely set among them, are multitudinous speck-like particles, which moreover extend their sway throughout the clear space. The darker portion of the yolk occupies here about two thirds of the whole egg cavity, and has scattered a few of its granules through the remaining third. Finally, the whole egg is filled by such coarse matter, but not uniformly; it still appears in distinct aggregations, (Pl. 8, fig. 15,) which, when first seen, dimly resemble so many granulated cell contents, the clear spaces between them representing, as it were, the cell walls. The granules are, again, finer than in the last egg, but more numerous in each heap.

The interspaces of these granular clusters constitute one of the several forms of albuminous concretions which remain to be noticed. In the present case they come nearest to the drop-like form; in fact, a slight approximation of the groups would complete their tendency to a globular arrangement, and end in perfect identity. However, the prevalence of granular cumuli throughout the egg is not always concomitant with the obliteration of the clear space, for at times the latter is still present over at least one fifth of the whole egg, (Pl. 8, fig. 17a,) whilst the components of the former have become dispersed more evenly through the previously clear interstices; and, moreover, they are considerably augmented and intermixed with clearer, less refractive, and less angular cell-like forms (Pl. 8, fig. 17b). Even till quite a late period an egg of $\frac{1}{32}$ of an inch in diameter may be found, now and then, spotted with spherical, clear, and very hyaline globules of albuminous matter, (Pl. 8, fig. 16a, 16b,) so closely resembling the germinal vesicle, that nothing but their number, their much smaller size, and their easy diffusion by the slightest pressure, marks them as belonging to an entirely different category.

Here, again, it is not irrelevant to insist upon the presence of a wall around the germinal vesicle, as additional evidence for its existence may be derived from the conduct of the clear spaces just mentioned, whose origin and mode of formation we know so conclusively that we can readily foretell how easily pressure would cause them gradually to fade away by diffusion among the neighboring granules; whilst the germinal vesicle exhibits considerable elasticity when pressure is removed, and will not burst till the last moment, if we may so express it, and then very suddenly, as if it had sustained great tension in some kind or other of restraining envelope.

There remains but one question to answer respecting the granular period in the growth of the yolk, before we arrive at the turning point, which reveals to us an entirely new and important feature in the life of the egg, namely, the formation of genuine yolk cells. How constant are the denser rings (Pl. 8, fig. 18a) of granular matter, already mentioned above, which may be seen in eggs of about $\frac{1}{30}$ of an inch in diameter? It is not yet possible to answer definitely this question; but this much is certain, that such phases are so frequently met with as to warrant the conclusion that they are to be considered as the prevailing state of the egg at this age. The granules of the rings are rather coarse, but not darkly outlined (Pl. 8, fig. 18b) nor irregularly shaped as heretofore, and the lighter circles exhibit only the faintest traces of minute, dot-like particles. In eggs considerably larger than this, (Pl. 8, fig. 19b,) we may meet with two rings of similar structure, (fig. 19,) separated by corresponding clear spaces.

SECTION III.

DEVELOPMENT OF THE YOLK CELLS.

Formation of the Ectoblast. Thus far we have considered the yolk as a whole. We now proceed to describe its cellular development.[1] The first change noticeable

[1] Thus far we have employed, in our descriptions of the egg and its contents, the nomenclature generally in use to designate its different parts, and those of the cell. But this nomenclature, framed to express particular views respecting the mode of formation and the functions of these parts, is completely theoretical in its meaning. It appears desirable, therefore, now that we are about to consider more fully the origin and successive growth of the yolk cells, to discard every technical expression which may imply a theory, and to adopt such only as designate the natural relations of the objects under consideration, especially since the views to which we have arrived cannot be reconciled with the theories which the current nomenclature is intended to express. For instance, in the case of a nucleolated cell, the outer envelope is described as formed *around* a nucleus, in which latter the nucleolus is developed. The outer cell membrane would thus inclose, at a later time, a mass accumulated around a *nucleus* already formed, as its name implies, and the nucleolus would be developed *within* the nucleus. For similar reasons we shall, hereafter, also avoid the expressions "parent and daughter cells." But, whatever be the mode of origin of cells and of their parts, there is, in a perfect cell, an outer envelope, containing another vesicle, in which is seen another smaller body. These parts are therefore designated in the sequel

in the aspect of the yolk, at the period of initiative cell genesis, is the hyalescence of the coarser granules,[1] and a rounding of their contours (Pl. 8, fig. 20a). At this time the egg is about one sixteenth of an inch in its mean diameter. (Pl. 8, fig. 20.) The recurrence of a superabundance of albumen is here presented, although in a manner already familiar, namely, in the drop-like form, yet with an essentially different anticipation. The function initiated at this period would lead us to suspect, nay, almost to demand, that something more than an adventitious globular concentration of amorphous substance must be silently working before us. And so easily is this suspicion put at rest, in a positive manner, that we very soon forget that there was once a moment of hesitation respecting the nature of this development. It has already been stated, that there is a difference in the progressive development of the smaller ovarian eggs and those which afterwards appear in separate sets, corresponding to the number of eggs which different species of Turtles annually lay. The eggs which we are now considering belong to the earliest set of somewhat larger eggs, which appear in definite numbers, and may be distinguished from the innumerable mass of smaller eggs scattered through the whole ovary.[2] I have further observed, that the youngest Chrysemys picta found in copulation had no larger eggs than these. It is, therefore, plausible to suppose that the changes which now follow, in the development of the yolk, are the natural consequence of a first connection of the sexes, which is repeated twice annually, for four successive years, before the eggs are laid; as will be shown more fully in another section.

But, let us return to the eggs in which the formation of the yolk cells is just beginning. The instant that water is allowed to act upon a portion of the yolk,

by the following names: *ectoblast* is applied to the outer envelope; *mesoblast* to the so-called nucleus; *entoblast* to the so-called nucleolus; and, when this contains a still smaller body, this is called *entosthoblast*. In the nomenclature of the egg, similar objections may be raised against the use of germinal or germinative vesicle and dot, as neither of these parts has the slightest reference to the formation of the germ. We shall therefore designate them, henceforth, as some embryologists do, by the names of the Purkinjean and Wagnerian vesicles. Applying our nomenclature to a comparison of the egg with the cell, the *yolk membrane* is to be considered as an *ectoblast*, the *Purkinjean vesicle* as a *mesoblast*, the *Wagnerian vesicle* as an *entoblast*, and the *Valentinian vesicle* as an *entosthoblast*.

[1] By the "hyalescence of the coarser granules," it is not meant that already existing angular, coarse, dark granules become hyaline, but that they disappear now, as they have again and again been changed before, and clearer and round bodies take their place; the action of some novel influence, probably the fecundation, inducing the genesis of new forms.

[2] Comp. p. 460. The eggs of intermediate sizes represented on Pl. 9 were observed out of the breeding season. After eggs like that of fig. 10 have been laid, those of the second set (fig. 8) soon grow to the size of fig. 9; those of fig. 5 and 6 to that of fig. 7; those of fig. 1, 2, 3 to that of fig. 4; and a new set, like the eggs of Pl. 8, fig. 20 and 21, start in advance of the smallest ovarian eggs, which cannot yet be distinguished in sets.

the hyaline masses swell slightly, and the internal portions lose their homogeneity: multitudes of faint granular particles appear suddenly; they dance about their confined sphere in a zigzag quiver, and finally their delicate boundary wall, which by this time has become unequivocally demonstrated, bursts suddenly on one side, and extrudes at a single contractive effort nearly the whole horde of its vivacious motes, assuming itself by this loss a wrinkled, unsymmetrical, much diminished shape, but still holding a few oscillating corpuscles. It may yet, perhaps, be doubted that there is a cell wall, according to the usual acceptation, embracing these homogeneous globules of albumen; for the envelope just displayed soon falls and crumbles to atoms, identical apparently with those which not long before rushed from its embrace, whilst a genuine cell wall, so called, disintegrates only under the process of decay. This, however, is only a matter of degree after all: both fall to atoms; the former soon, by reason of its undeveloped nature; the latter holds out longer, because of the greater adherence of its component particles. Moreover, on account of its very slightly changed density and refraction, the former is not recognizable as a separate layer from the mass within; whilst the latter is differentiated by the great predominance of these two features, which are lacking in the young cell.

Here, then, we have essentially, nay, in every sense, a cell, a hollow layer of spherical surface, derived from the lateral adherence of the superficial particles of a homogeneous globule.[1] It is not a cell formation by the hollowing out of a solid substance, forming at first a very thick wall, which would stretch by the increase of the contents, as it gradually surrounds a larger space, till it thins out to the ordinary crassitude of such envelopes. Never, throughout the whole range of cell development in the egg, is there the merest hint at this mode of genesis. From the beginning to the end of the growth of the ectoblast it ever preserves the same thin stratum, apparently of a single layer of corpuscles, and moreover the same tenderness and the same refracting power. Nor can we compare this process to the received mode of cell origin, according to which a wall is condensed around and upon a "nucleus,"[2] for the mesoblast is often absent

[1] See p. 454, on the primary cell wall of the yolk.

[2] Since the word *nucleus* implies a body around which something condenses, and nothing of the kind takes place here, the name *mesoblast* is certainly a much preferable designation for that part of the cell which is commonly called nucleus. The new names proposed here for the parts of a cell have the further advantage, that they may be applied for the whole body which they are intended to designate, as well as for its envelope. An incipient ectoblast is a homogeneous mass, which afterwards has an envelope distinct from its contents, and so is the mesoblast; even the entoblasts may become vesicular and contain one or more entosthoblasts. It is therefore desirable that the nomenclature of the cell should be applicable to these different stages of its development, which the names of *cell*, *cell wall* or *cell contents*, *nucleus* and *nucleolus*, are not.

in quite large cells; in fact, an egg little more than one sixteenth of an inch in mean diameter (Pl. 8, fig. 21) contains numerous cells of considerable size, (Pl. 8, fig. 21a,) no one of which contains a mesoblast. Nor can it by any possibility be advocated, that these cells are the contents of other cells, for no others exist; even in a much larger egg, up to full-grown ones, this holds good just as undoubtedly, for in such a mass of yolk as larger eggs contain, the mesoblasts and ectoblasts have respectively very peculiar and unmistakable properties, not to be confounded with any other cell contents. The resemblance which this mode of cell formation bears to that commonly received is far more apparent than real; yet, paradoxical as it may seem, we must confess that it is very difficult to express the essential character of the difference which separates these two different modes of viewing the subject.[1]

An ectoblast, which, under a power of five hundred diameters, appears about one-eighth of an inch through, in its greatest diameter, (Pl. 8, fig. 21a,) has attained its greatest transparency. The ectoblasts preserve this remarkable transparency up to the full accomplishment of their growth, which is not reached, however, till the egg is fully ripened.

The ectoblast has a remarkable plasticity and resilience, which the mesoblast also shares, existing from the youngest (Pl. 9, fig. 8a, K) to the oldest stages, (Pl. 9, fig. 11h,) in consequence of which the cells may squeeze and worm their way among each other, and yet, when free, return to their original rotundity. Nor is this all; for, besides their impressibility, they have an equally great extensibility, (Pl. 9, fig. 8a, A, M, N,) which may best be seen after they have been left in contact for a while and then forced apart, by setting the ambient fluid in motion, when their adherent portions stretch out with long arms. However, beyond a certain extension of these projections the agglutination ceases, and each cell returns to its proper sphericity.

Beyond the fact that the slightly irregular rough surface of the smaller cells becomes, in the larger cells, a remarkably smooth, polished, yet not glittering superficies, presenting on the whole the appearance of a beautiful sphere of glass, we have nothing further to add as regards this special part of their organization, except to mention the action of heat, which collapses the cell wall upon its mesoblast, the latter remaining undisturbed, whilst the entoblasts are fused into a

[1] Properly to consider this subject, it should be introduced when investigating the mode of origin of the mesoblast, as we view this process. Since the growing ectoblast, apart from its mesoblast and entoblast, varies but little, excepting in size, from the time of its birth, we may now complete the description of its phases in a few words, and then proceed to describe the development of the primary alteration of its homogeneity, that is, the initiative step in the formation of the mesoblast.

single mass, which but faintly shadows forth the parietes of its constituents (Pl. 9, fig. 11f, *a*, *b*, 11g).

Formation of the Mesoblast. We have already mentioned, that there is no constant size at which the ectoblast develops its mesoblast. A minute ectoblast may be seen with a well defined mesoblast, (Pl. 8, fig. 22, *c*, *d*, and Pl. 9, fig. 8a, F, *b*,) and another four times its diameter (Pl. 8, fig. 21a) without any, and so on, at various intermediate magnitudes. Some cells have even their entoblasts (Pl. 8, fig. 23b, *a*, *b*, 23d, *d*, *e*; Pl. 9, fig. 8a, D, E, F) at a diameter, which, in others, presents only a homogeneous content. However, to give, with some sort of precision, an idea of the limit of the development of the mesoblast, we would state, that, under a magnifying power of five hundred diameters, there cannot be found a single cell, except perhaps with rare exceptions, which presents to the eye a diameter beyond one eighth of an inch, that is, $\frac{1}{4000}$ of an inch in actual size, without a mesoblast.

As a natural consequence of this diversity of size in relation to the appearance of the mesoblast, this body may be much larger in one cell, than in another of the same diameter; for as soon as it is defined it begins to grow, and continues to increase in size, along with the ectoblast, till the egg drops from the ovary to enter upon a new phase of life. Unlike other mesoblasts, the mesoblast of the yolk cell is not arrested in its development when the ectoblast has reached a certain size, and does not remain as a mere indication of past activity, but ever persists in manifesting very active internal changes within its constantly increasing bulk. With the exception of the germinal vesicle, the mesoblast of the yolk cell, when at its full development, is the largest known, at times measuring about $\frac{1}{100}$ of an inch in diameter. With these preliminary remarks, one may be forewarned to expect here a mode of development of mesoblasts hitherto unnoticed or disregarded in other centres of cell evolution.

The earliest indication of a mesoblast is manifested by a slight haziness at one single point within the ectoblast, close against its wall (Pl. 9, fig. 8a, J, L', *b*). At first undefined and vanishing at its border, it gradually assumes a sharp, spherical outline and a pearly opacity reminding one of the primary physiognomy of the ectoblast; but yet it is of a denser nature than the latter. The size at which it gains its definiteness of contour varies in different cases, the hazy state of one often exceeding the clearly limited mass of another by several diameters. The attachment to the wall of the ectoblast is at times loosened almost as soon as the outline is perfected (fig. 8a, J); however, not long afterwards, every mesoblast becomes free, and may be found, for the rest of the interovarian life of the egg, at the centre of the sphere, whence it is derived.

In the case of the formation of a mesoblast in a most minute ectoblast, the appearance produced is as if the latter originated round the former, instead of the reverse, which is the natural process, as we have lately demonstrated; and this, no doubt, has given rise to the prevailing view of their genetic relation. This appearance may, however, very readily be accounted for, with the object in sight; but to put the picture before another's eyes in the mien of words, introduces an element in the demonstration always difficult to overcome, and most tryingly unprecedented in the present instance, not only from the intrinsic novelty of the subject, but also because a totally different interpretation of the cell genesis, in other bodies, has swayed the minds of nearly all previous investigators. Hence we must beg an unwonted indulgence wherever, in our descriptions, there appear an unusual redundancy of words, and repetitions of the same idea under different guises.

If there had ever been found a free cell which in the least resembled the mesoblasts already developed in other cells, then the office of originating around itself a certain more transparent spherical substance, such as we call ectoblast, might possibly have been attributed to it. But in no instance has such a cell been discovered, nor any one at all approximating its feature; on the contrary, as we have already shown, all homogeneous cells which appear after the irregular granular state of the yolk are endowed with the physiognomy of ectoblasts. The nearest approximation to such a mode of cell formation is exhibited in those instances where the mesoblast nearly fills the ectoblast; but this occurs not in the minutest cells only, (Pl. 9, fig. 8a, K, F,) it is equally seen at all stages of yolk cell growth, (Pl. 9, fig. 8a, A, B, C, D, fig. 6b, fig. 11d, *a*, and fig. 11e,) even in the largest eggs. Always, wherever a so-called nucleus is found, there is present a clear enveloping substance of lesser or greater thickness. It would, therefore, be just as reasonable to argue that the largest cells originated full-grown around this nucleus, which nearly fills them, as it would be to assert that this obtains in the minutest cells which present such features, excepting perhaps for the fact that these last are nearer related to the dimensions at which the like are generated; for, in truth, as far as argument from appearances is concerned, there is no difference, except in size; and it requires but a moment to magnify the smaller to such an amount that they will appear identical in every respect with those actually far exceeding them in bulk (Pl. 9, fig. 8a, K and C, or fig. 7d). How easily may we, on the contrary, trace the converse mode of genesis! How naturally can one follow the steps of the various stages, from a simple, clear cell, at first condensing a portion of its contents into a cloudy mass, till the cloud grows more and more defined in outline and globular in shape, and at last displays itself as a perfect sphere, which finally proceeds to grow, till, by the time the egg has a shell, it absolutely fills the ectoblast (Pl. 9a, fig. 33b, 39a — 39d)! Now it is in these latter stages that the development of the mesoblast may most readily be mistaken for the primary cell genesis; — a well matured cell for one just forming! Such an error however is excusable only in one who has taken but a glance at the yolk in certain stages of its development, — nay, hardly even then. But when the whole series of phases is followed with patient eye and thought, it is impossible to fail in recognizing the true and only prospective system of cell growth, the plan according to which each and every yolk cell has originated, advanced, and finally received the last touch, to fulfil the end for which it was intended, from the beginning, by its projector.

It is only during the beginning of its life that the mesoblast preserves uniformly any thing like a spherical shape. As soon as it has defined its outline clearly, growth ensues, and a more or less irregular, and very often angular, contour bounds its contents, throughout the interovarian life. As regards the last-mentioned shape, were it not for the peculiar reaction which water produces in its contents, causing a condensation in a network form, with less or greater meshes upon its wall, (Pl. 9, fig. 2a, *a*, *b*, *d*,) it might be mistaken for an entoblast; but the entoblast is not at all affected by such a reagent. Moreover, mesoblasts with crystalline configuration are often met with, which contain entoblasts bearing every characteristic of those observed in older phases of development (Pl. 8, fig. 23d, *c*, *k*, *l*). However, it is only at about this age, when the egg measures from one tenth to one eighth of an inch in diameter, that such an unusual angularity of the entoblasts obtains; the subsequent stages, up to those of the full-grown ovum, are characterized by irregular oval or spheroid shapes, and, rarely, with here and there a perfect sphere (Pl. 9, fig. 6a, *a*, *b*, *e*, *g*, and fig. 11i). Contemporaneously with irregularity of form it assumes also a change in color, till very soon, at about the most angular phase, it has passed from a faint to a dark yellowish tint, which it ever after retains as a characteristic complection, distinguishing it from the brilliant, clear, golden yellow of the crystalloid entoblasts.

With reference to the reaction which water produces upon the contents of the mesoblast, we may add a few more remarks in detail, in order to bring the changes thus produced to bear upon the question of the existence, if not of a wall, at least of a denser exterior layer surrounding the entoblasts. Indeed, the presence of such a layer cannot be questioned; for, whilst it forms the basis upon which the contents collapse in wrinkles of coarser (Pl. 9, fig. 2a, *d*, 3a, *c*, *d*, 12, *a*, *b*, *c*) or finer folds, (Pl. 9, fig. 2a, *a*, *b*, 3a, *a*, *b*, *g*, 7d, 7e, 7f,) anastomozing with each other like the meshes of a network, it yet preserves exteriorly its form intact, except in some cases, where the cause of the shrinking within has distorted (Pl. 9, fig. 12, *a*, *b*, *c*) the foundation upon which it has impelled the more central material. In this state, very little pressure is required to crush into angular fragments the now brittle shell of the mesoblast, and, by a trifling disturbance of the yolk fluid, the broken parts may be made to roll over till they display their inner surfaces covered with ridges, (Pl. 9, fig. 12, *d*, *d'*,) or present a profile of their thickness, showing in an indisputable manner that this thickness is uniform throughout the whole extent of the spheroid mass, to which it bears a very small proportionate diameter. Now, the very fact that the water passes through the exterior of the mesoblast, leaving it intact, and powerfully reacts upon that which it last comes in contact with, is of itself evidence enough to show that the acknowledgment of a cell wall here depends merely upon our interpretation; and whether a denser layer, inclosing a more fluid substance, can be called a wall, or is to be considered only as the extreme of a mass gradually increasing in density centrifugally, from centre to superficies. The latter view, fortunately, cannot be sustained without the help of questionable reasoning, when we refer to the manner in which the entoblasts, as they gorge the parental matrix, press outwards, in angular prominences, (Pl. 9, fig. 6a, *c*, *d*, *i*, *j*,) the thin resistant layer which bounds their field of development, and persist in restraining them from projecting uncovered into the hyaline fluid of the primary cell.[1]

Again: the existence of entoblasts, without a cell wall to contain them, would be an unprecedented phenomenon; yet here such an envelope is denied, inasmuch as there does not appear any visible differentiated layer of protein compound corresponding to the usually received definition. But, as it has been shown regarding the wall of the primary cell, (which wall, as likewise here, is not visible at first on account of its lack of refractive powers,) there is a thin stratum, sufficiently tenacious to restrain the more fluid contents, and this stratum sustains a very different reaction from the latter when immersed in water. To such an envelope, whether visible or not, most certainly the title of cell wall belongs; and under this mode of consideration we may extend the definition of a cell wall beyond the hitherto stereotyped bounds, and embrace a broader and more general view of its essential nature, characterizing it as a hollow, more or less spherical, layer, of indefinite density, tenacity, and refraction, which surrounds the field of some definite, though isolated and homogeneous, function.

When speaking of the plasticity and resilience of the ectoblast, we have already

[1] As the entoblasts of the yolk cells have generally been described as crystalloid bodies, swimming either free in the yolk or surrounded by a transparent cell wall, (J. MÜLLER, Ueber den glatten Hai des Aristoteles, Ak. d. Wiss., Berlin, 1842, p. 37, and Rathke, Entwick. d. Schildkröten, p. 5,) and as the mesoblast which incloses them has been overlooked by all previous observers, we have not been tired in accumulating proof upon proof, in order to show that they are, in every instance, actually inclosed in a sac, and that this sac, and not the crystalloid body, is the mesoblast of the yolk cells.

mentioned a similar peculiarity in the mesoblast; but it is proper to revert to the same subject in this place, especially as some more details are necessary in another point of view. It is to the homogeneous fluidity of the contents of the mesoblast that we would now call particular attention.

Let any one glance at a quantity of yolk cells squeezing their way among each other, and observe the easy mobility of the entoblasts as they oscillate in the mass of now constantly changing, unstable shaped matrix, flying from side to side almost as if they were thumping about in an empty space, and then say, whether the mass within the mesoblast which surrounds the entoblast is a connatural fluid, equidense throughout, or, centrifugally denser, as the collapsing upon the cell wall by aqueous reaction might suggest. To the latter view we have no inclination whatever; but to the former we must give our unqualified assent. We have characterized so particularly the movements of the entoblasts under disturbing influences, in order to render more prominent the fact that these bodies return with unerring certainty to their proper position at the centre of their parental domain, as soon as they are relieved from the contact of neighboring cells similarly affected. Whether this phenomenon is to be ascribed to the same centripetal power that influences the origin of the entoblasts in a central rather than a lateral position, we can only conjecture; but it seems natural to suppose that there must be some unknown relation between the two, and that perhaps the one may be the complement of the other. One word more in reference to the conduct of the mesoblasts, after water has burst the parent cell. Under such circumstances the mesoblasts become easily agglutinated to each other by the slightest pressure, and their parietes are totally obscured, so that one might suppose the yolk cells had contained immense irregular mesoblasts (Pl. 9, fig. 12, *e*, *f*).

From the time of the origin of the mesoblast up to that age when the egg measures about one sixth of an inch in diameter, the mesoblast seldom exceeds the semidiameter of the ectoblast, (Pl. 8, fig. 23d; Pl. 9, fig. 6a, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *j*,) and often falls short of even that extent, especially just after that exceptional state, when the rather minute cells, ectoblasts, rapidly amplify their mesoblastic progeny (Pl. 8, fig. 23b and 23c) till they are nearly filled with them, and then just as quickly outstrip them in increment of bulk. At the latter end of this stage the ectoblast begins to fail in maintaining its greatly superior size, (Pl. 9, fig. 6a, *a*, *b*, fig. 7d, 7e,) and the mesoblast from this time forward gradually encroaches upon the fostering matrix, till the latter, in a full-grown egg, is impersonated by a moderately thin layer, resembling, in its beautiful transparency, a halo about a cluster of golden brilliants. Thus terminates the career of the mesoblast in yolk cells, as far as its activity in the life of an interovarian egg is concerned; but another more remarkable phase is still to be gone through before it ceases to be independent. This feature of the life of the mesoblast, however, more properly belongs to another chapter, in which it will be shown, that the once free cell may finally be recognized as entering bodily, but not in its present entity, into the formation of the embryo.

We now proceed to consider the origin of the crystalloid entoblasts, of which we have already so often spoken in connection with the mesoblast.

Formation of the Entoblast.[1] In the same egg in which a mesoblast first appears, the entoblasts also begin to develop, but singly at first (Pl. 8, fig. 23b, *a*, *b*, 25, *d*). Their number very rarely amounts to more than two or three in each mesoblast, (Pl. 8, fig. 23d, *c*, *j*, *l*, fig. 25, *a*,) until the egg is from one eighth to one sixth of an inch in diameter. Casting the eye over the field of the microscope, there may be seen here and there a few of the minuter cells, containing mesoblasts, which are rendered more conspicuous by the presence of a dark dot in the centre of each (Pl. 8, fig. 23b, *a*, *b*, 23d, *d*, *f*, *g*; Pl. 9, fig. 3a, 6a, *n*, *o*, *p*): this dot is the nascent entoblast. Unlike the faint looming up of the mesoblast, the entoblast, minute as it may be in its incipient state, shows itself clearly and well defined, and usually with an irregular angular outline. The central orientation of this body, and its fac-simile repetition, in the same focus of centripetal influence, have been noticed before as a remarkable and unusual feature in concentric cell development; and now we would, in this its proper place, follow more in detail the elaboration of the design involved in its peculiar mode of growth.

Rarely is a single entoblast permitted to attain any 'considerable size alone; but, soon after the declaration of the first, two or three more appear in the field, (Pl. 8, fig. 23d, *e*, *j*, *k*, *l*, 25, *a*; Pl. 9, fig. 3a, *c*, fig. 8a, D, fig. 6a, *m*,) and thus, forming a cluster, proceed together in adding to their bulk. Soon, in a little older egg, more are added to the cluster, (Pl. 9, fig. 6a, *d*, *f*, *g*, *h*, *i*, *j*,) and again still others, (*a*, *c*,) until their number is beyond estimation, and the mesoblast is surcharged with them to its very wall (*b*). By this time the mesoblast has usually exceeded in diameter the radius of the ectoblast (*a*, *b*, *e*). In two mesoblasts of the same size, (*a* and *b*, also *c* and *e*, or *j* and *f*,) the entoblasts differ both in number and size; those in one being oftentimes equal in length to the diameter of their parent, (*a*, *j*,) whilst those in another are mere grains in comparison. The feature that particularly characterizes the entoblasts, and is prevalent from the beginning up to this period, is a sharp angularity, which at times gives a spiculate appearance to the clusters.

[1] The name *entoblast* may apply to that part of the cell which is commonly called nucleolus, whether it consists of a single dot, or is made up of a larger or smaller number of such bodies. However, while describing the formation of the individual dots, we shall use it in the plural. We shall also have occasion to use the name of mesoblast in the plural, to designate the parts into which it divides. See Ch. 2, Sect. 4.

After this comes a great change, not only in the yolk cells, but throughout the whole organism of the egg. The entoblasts begin to decrease in number, and lose their angularity (Pl. 9, fig. 7c, 7e); the mesoblast, as we have before mentioned, encroaches upon the hyaline area of the ectoblast; and, to crown the whole, the Purkinjean vesicle changes its complicated cellular structure (Pl. 9, fig. 5a, 5b, 5c) into one which is almost perfectly homogeneous, (Pl. 9, fig. 7a, 7b,) and this too without the least sign of any new or external influence, so far as we have been able to penetrate the process of this development.[1]

But, to return to the continuance of the entoblastic changes, let us first note the numerical decrease of the waxy crystalloid bodies as the primary indication of any signal divergence from the hitherto uniform line of conduct; and, secondly, the rounding off of their angles. It is a matter of some doubt as to whether the existence of a few entoblasts in each cell is owing to the actual decrease in the number of each cluster, or to the total dissolution of the ectoblast, mesoblast, and entoblasts, and the regeneration of new ones in their stead. Now if the latter supposition be true, it is hardly possible, that, during the evanescence of these bodies, some should not have been found in a transitory state, either a mesoblast without an ectoblast around it, or an ectoblast without mesoblast, or an entoblast totally exposed, or a mesoblast without an entoblast; and, since no such changes are noticed, we are forced to adopt the former conjecture, which has at least a certain amount of evidence in its favor. This we will attempt to support by referring to an egg (Pl. 9, fig. 7) a little older than the last, in which, amid cells as yet containing angulated entoblasts, (Pl. 9, fig. 7f, 7g,) may be seen, here and there among the largest, some cells in which the sharp edges of the entoblasts have begun to be rounded (fig. 7c, 7e) and the total number of entoblasts has considerably decreased, though they still hold their angular features; but soon these angles are lost and superseded by rounded contours embracing irregular but more equal sided masses, varying from pyramidal to cubical, (Pl. 9, fig. 8a, A, A, A,) or from oval to spherical forms (fig. 8a, B, C, C). In an egg three eighths of an inch in diameter, (Pl. 9, fig. 8,) and in which the number of entoblasts may vary from five or six

[1] In view of such a parallelism of changes, we cannot but conceive that there must be some total action, to which each special influence, in the several organisms of the egg, is secondary. However, it is not so much the presence of such a force, as its nature and origin, — whether it is inherently an idiosyncrasy of the region in which it operates, or whether it is generated by some periodic external agency, as for instance the repeated acts of copulation, — that the mind would fain decide upon. Inasmuch as the egg, at this age, is far from full-grown, but rests unspecialized among many of the same size, it cannot be advocated that it may be subject to any external influence, and that too whilst those a little smaller remain unaffected; and so we must fall back upon the former and more probable explanation, and, for want of additional facts, leave it, about as in the beginning, an unsatisfactory matter of conjecture.

down to a single one, these last phases become most frequent; nay, in fact, they prevail to the nearly total exclusion of the others. However, the entoblasts cannot all be traced back to a more angular state, since the minutest, the moderately small, the medium sized, and the largest, indeed, the whole range of cellular developments, display this new character; and among some of these there must certainly be a totally new genesis, or else whence come the supplies that keep up the proportionate number in relation to the increasing bulk of the egg?

This is answered by a survey of the field, where every minute cell will be found in the process of generating, not, as formerly, angular, (Pl. 9, fig. 6a, *p*, *o*, *n*, *l*, *m*, *h*, and 6b,) but more or less rounded, irregular entoblasts, (Pl. 9, fig. 8a, D, D, E, F,) which in succeeding and older stages are repeated, first, by one, (Pl. 9, fig. 11d,) then by two or three, (Pl. 9, fig. 11e,) and so on up to as many as six counterparts (Pl. 9, fig. 11f, 11g, 11h). Yet they do not always iterate themselves correspondingly with the amplification of the generating cell; but as an equivalent, the bulk of a single one or two is enlarged so much (Pl. 9, fig. 11e, 11f, 11h, *a*, 11i, *c*) as frequently nearly to fill the parent. Here we have, then, two distinct modes of originating a new phase in entoblastic life: the one a process of remoulding and fusion, the other a totally new genesis.

In process of time, with the increasing size of the egg, up to the full ovarian growth, the entoblasts add more to their number, or enlarge each one its own proper boundaries, till in the former case a cluster sometimes contains a dozen waxy masses, (Pl. 9, fig. 11g,) and in the latter instance the mesoblast is nearly filled by one, two, or three of its progeny (Pl. 9, fig. 11f). From this time forward, whatever happens to these bodies, as regards multiplication or change of size, belongs exclusively to an extraovarian career.

The thick, dark, oily outline, which characterizes their contour from the beginning, is duplicated in those entoblasts (Pl. 9, fig. 11i, *c*) which belong to mature ovarian eggs; this may even be seen in younger stages, but not by any means so distinctly. The distance between the outer and inner lines indicates a very thick wall, composed probably of a substance of a brittle nature, judging by the fissures resulting from pressure; and the dark, thick outlined, golden-yellow contents doubtless are fatty, and more or less fluid or viscid. The latter term appears to characterize more correctly their nature, when we consider, that, after the application of heat, although this causes the waxy masses to blend with each other, they still preserve enough of their solidity to prevent them from losing altogether their irregular outline, as would happen were they in a fluid state.

Let us now glance at whatever characteristics have not been as yet brought to notice. We have already pointed out the insensibility of the entoblasts to the action of water, when speaking of the reaction of the latter upon the mesoblast, and on this score need not make any further remarks; but we can very properly instance some particulars in regard to the effect of heat and acids. A full-grown ovarian egg, being thoroughly boiled to the centre by immersion in hot water for the space of three minutes, was opened, and portions of its contents from different depths put in the field of the microscope, when it instantly became evident, that, throughout the whole yolk, every cluster of crystalloid entoblasts had fused its individual components, each one to its neighbor, so that, in connection with the greater transparency that had followed this reaction, it was almost impossible to distinguish any thing but a faintly polygonal light yellow mass. Acetic acid at first swells the ectoblast till it bursts, then produces an effect similar to that of water upon the mesoblast, and finally destroys the same with the entoblasts, after having rendered the whole very transparent. Caustic potash swells the ectoblast enormously, and then dissolves its contents very rapidly. Pressure produces a curious appearance, which has been mistaken by some for a normal feature of the entoblasts, namely, parallel fissures intersected here and there by others obliquely transverse to them.[1]

SECTION IV.

THE PURKINJEAN VESICLE.

When treating of the egg as a whole, in its earlier stages, the primary phases of the Purkinjean vesicle[2] were included, as necessary to the understanding of the character of the egg, when viewed in the light of a cell; and now that we wish to make a separate, special study of the Purkinjean vesicle, besides referring to former pages,[3] a rapid recapitulation is by no means superfluous, in order that there may be continuity in the illustration of the subject. We have already spoken of the Purkinjean vesicle as being originally a minute concretion of solid matter against the wall of the primary egg cell, which has no definite size at the time; also of its having no part in originating the egg cell; of its great transparency; of the subsequent existence of a distinct wall around it, under a form sufficient to restrain its fluid contents from intermingling with the yolk; and

[1] See J. Müller, Ueber d. glatten Hai, q. a., p. 38, and Rathke Entw. d. Schildkröten, p. 5.

[2] It has already been stated above why we prefer to designate this part of the egg by the name of Purkinjean vesicle, rather than apply to it the more usual name of germinal or germinative vesicle. See Sect. 3, p. 463, note 1.

[3] Comp. Sect. 1, 456.

finally, referred to the special description of its further development in a chapter set apart for the subject. We will now, in continuance of the subject, first consider the wall of the Purkinjean vesicle, which may be characterized as excessively tender, especially in the older eggs; and as regards its thickness, there is hardly any appreciable distance between its outer and inner surfaces till the last days of its interovarian life (Pl. 9, fig. 11b).

No two eggs of equal size contain Purkinjean vesicles of the same diameter, and a larger egg may still have a vesicle not surpassing in size that of a smaller one. This disproportion remains constant throughout the ovarian life of the egg. After the Purkinjean vesicle has defined itself, it continues to increase in size for quite a length of time, before any thing appears to disturb the homogeneity of its contents; but at last, about the time when its diameter equals perhaps one fourth that of the egg, a faint spot or two obtrudes upon the clear field (Pl. 8, fig. 8a). Difficult to recognize at first, these spots soon make plain their position (fig. 11a and 12) on the wall, where they remain, as well as those succeeding them, till quite late in the life of the parent. When the Purkinjean vesicle has reached a size but a little larger than that of the last, these spots, the Wagnerian vesicles,[1] almost entirely cover the wall of their parent, simulating, by their clearness and roundness of contour, drops of dew lining a glass globe (Pl. 8, fig. 14a). It is obviously best to describe here, at the starting point of these bodies, the mode of origin of the Wagnerian vesicles, the entoblasts of the egg cell and of the little dots, the Valentinian vesicles, the entostholblasts of the egg cell, which arise in them. At the same time it will not be amiss to indicate the parallelism which may be traced between their growth and the mode of genesis of the yolk cells.

The clear, transparent nature of the younger states of the Wagnerian vesicles is gradually lost in a certain measure, and superseded by a pearly or milky complection, bounded by a rather dark, soft outline, (Pl. 8, fig. 15a, *a*,) calling to mind the appearance of the denser species of Medusæ, or the bluish transparency of boiled cartilage; at the same time there appears a very bright, irrefractive, eccentric spot, (fig. 15a, *b*,) the Valentinian vesicle.[2] The latter increases in size (fig. 15a, *b*, *c*, *d*, *e*, *f*, f^1) at a greater proportionate rate than its parent, the Wagnerian vesicle, till at its final stage it oftentimes occupies three fifths of the diameter of the generating medium (fig. 15a, *f*, and f^1, fig. 22, *e*, 24b; Pl. 9, fig. 4a); yet even then it refracts so slightly as to be hardly appreciable; but in a certain light, owing to its great transparency compared with the pearliness of the surrounding substance, it appears darker than the latter, and under

[1] See note 1, p. 463, and note 2, p. 475.

[2] See note 1, p. 463.

all circumstances flat, as if disciform (Pl. 8, fig. 15a, f^1). These latter features obtain at a time when the egg is about from one eighth to one sixth of an inch in diameter; but subsequently, at no very distant period, the Wagnerian vesicles and their contents disappear, and give place to a homogeneous fluidity, which generally pervades the Purkinjean vesicle, and lasts for the remainder of its existence. However, this rarely happens in much smaller eggs; yet an egg with a diameter of one tenth of an inch (Pl. 9, fig. 1) may have a Purkinjean vesicle, (fig. 1a, *b*,) which, although perfectly free from Wagnerian vesicles, equals in size another Purkinjean vesicle containing numerous Wagnerian vesicles, (Pl. 9, fig. 5a, 5b, 5c,) and even belonging to a much larger egg (fig. 5). Respecting the presence of a wall inclosing the Wagnerian vesicle we have only to mention, that water breaks up its Valentinian vesicles into small, angular portions, which spread throughout its whole extent, though they stop within its outlines, (Pl. 8, fig. 24b, *a*, *a*; Pl. 9, fig. 4b,) evidently because of a resistant substance which does not yield to the reaction. This certainly is enough to substantiate the existence of a membrane, and moreover of one that has considerable stability, when we see that an hour's maceration, in one instance, did not destroy its entity (Pl. 9, fig. 4b). While speaking of the reaction produced by water, we may as well mention also, that heat applied by boiling does not seem to effect an appreciable change in the intimate constituents of the Wagnerian vesicles, but evinces its disturbing power in another manner by loosening them from the wall of the Purkinjean vesicle, and forcing the whole to cluster around the centre of the latter (Pl. 9, fig. 5a, 5b, 5c) in the form of a nebula.

The Purkinjean vesicle during all this time has been rapidly increasing in size, and becoming more and more easily recognizable externally, till, at the last-mentioned size of the egg, namely, when it has one sixth or one fifth of an inch in diameter, it may be taken from the bed of yolk in which it lies, without any other guide than the naked eye. But, on account of the excessive tenderness of the membrane of the Purkinjean vesicle, it is not possible to effect this, unless it be boiled within the egg, when the heat coagulates the albuminous contents to a sufficient consistency to allow its being lifted up on the point of a knife; but even then it hardly holds together, thus evidently evincing the presence of a smaller amount of albumen, and a greater quantity of oily substance, than can be found in older ones. In two eggs of this size that were opened after having been boiled, the side of the Purkinjean vesicle that laid next to the yolk sac was inverted slightly, (Pl. 9, fig. 5b,) probably owing to the contraction of the contents, and the pressure of the yolk. This phenomenon occurs to a greater extent in older eggs, and is obviously due to the increased amount of albuminous deposit, judging from the greater toughness of the Purkinjean vesicle when boiled. The homogeneous state of the contents of the Purkinjean vesicle usually appears about the time when the egg is one quarter of an inch, or a little less, in diameter (Pl. 9, fig. 7). The whole vesicle, as we have said above, is filled with homogeneous contents; but upon closer examination it may be perceived that the mass is composed of excessively minute particles, which the heat of boiling arranges in little clusters (Pl. 9, fig. 7b) that might easily be mistaken for a coarse granulation. This clustering is most evident at or near the centre of the field, where it seems to be denser and darker (Pl. 9, fig. 7a). For comparison with this, we will cite the figures of a larger egg, (Pl. 9, fig. 9,) more than two thirds grown, where the only difference from the last is, that the clusters of particles (fig. 9a, fig. 9c, *a*, *b*) are not so large, but more densely packed at the centre, and the Purkinjean vesicle is more deeply indented (fig. 9b). Another and little older phase (Pl. 9, fig. 10) offers a new feature in the contents of the Purkinjean vesicle; boiling has not had the effect to coagulate into clusters the minute corpuscles which form these contents (Pl. 9, fig. 10c, *a*); and, excepting perhaps that the central darker and coarser granules (Pl. 9, fig. 10a, 10c, *b*) whose brilliant refraction renders them so conspicuous are brought more closely together than is natural, there is nothing left but the deep indentation of the vesicle (fig. 10b) to indicate that a contracting influence has been at work.

The next and last step in the life of the Purkinjean vesicle is an almost total vanishing of its clusters, (Pl. 9, fig. 11b, *a*,) so conspicuous heretofore in the medium sized eggs when boiled; but, as these clusters grew more and more faint latterly, we are not taken by surprise at their nearly total extinction in the full-grown egg (Pl. 9, fig. 11). Still a few brilliant, darkly outlined granules, situated centrally, and not so coarse nor so numerous as in the last-mentioned vesicle, serve to cloud the contents which elsewhere are homogeneous. At this age, too, the wall (Pl. 9, fig. 11b) of the vesicle has become of sufficient thickness to allow a distinction between the outer and inner contour; but still we fear it is beyond the power of the pencil to give any idea of its delicacy. The extent of its indentation (Pl. 9, fig. 11a) gives an evidence of very strong contraction, by far more intense than has been known to happen in eggs of a smaller size. But what must be the infinitesimal minuteness of the particles composing the contents of this vesicle, when such powerful contraction only produces clusters of granules (fig. 11b, *a*) almost unrecognizable with a magnifying power of five hundred diameters!

The large size to which the Purkinjean vesicle has now attained renders its extraction an easy matter, when it has been hardened by boiling; and in this state it may readily be preserved in alcohol. Even the vesicle taken from an egg one fifth of an inch in diameter, after it has been boiled, may be put up in spirits and kept for reference, as may be seen in my embryological collection. I mention these trifling circumstances, only the more fully to satisfy the reader that these investigations were made upon parts of the egg duly isolated for a satisfactory microscopic examination.

SECTION V.

THE GROWTH OF THE OVARIAN EGG, AS A WHOLE.

Thus far we have described in detail the origin, the development, and the maturation of the several constituents of the ovarian egg of Testudinata. Now, in order to arrive at a full and comprehensive understanding of the general relations which exist between the several elements of this complicated structure, among each other as well as with reference to the whole organism of the egg, it is necessary to combine, in one view, all the details which have been before presented as separate and independent features. We have, indeed, up to this time, considered the different parts of the egg as constituting separate organs, as it were, growing each one independently, as regards the peculiar plastic force operating therein. We have shown that each of these parts is distinguishable from every other by dissimilar characters; and yet they are all connected by a superior power, which holds them in obedience to the one great law of correlation controlling the growth of every organized being.

In a former section[1] we have followed the growth of the egg as a whole, up to that period when the homogenity of its contents begins to be disturbed by the introduction of the yolk cells in the form of dark granules. At this stage the Purkinjean vesicle is a very clear globule, usually situated in that part of the egg which is most distal from the side where the granules appear (Pl. 8, fig. 4, 5, 6, 8, 9, 10, etc.). The next step brings an encroachment of the granular region upon that which surrounds the Purkinjean vesicle, simultaneously with the appearance of the Wagnerian vesicles in the latter (Pl. 8, fig. 13a, 15, 17, 17a, 18a, 19); thus exhibiting no inconsiderable change in the internal life of the egg. In the succeeding stage, the yolk granules are replaced by mesoblasted cells, (Pl. 8, fig. 22, *a–d*, 23, 23a–23d, 24, 24a, 25, *a–c*, etc.,) accompanied by an enormous increase of the Purkinjean vesicle (Pl. 8, fig. 22, *e*, 24b); from this time also the differentiation in the size of the yolk cells becomes conspicuous, those around

[1] See Sect. 1, p. 451–457.

the Purkinjean vesicle[1] being much smaller (Pl. 9, fig. 6b) than those nearer the centre of the egg (fig. 6a); and between these two extremes a gradual increase in bulk from the former to the latter is readily traced. This feature holds good throughout the succeeding phases of the ovarian egg, even to its full development (Pl. 9, fig. 11d–11g).[2] About this time, also, there appears a whitening of that side of the egg where the Purkinjean vesicle is situated. This whiteness increases in intensity and breadth as the egg enlarges, till in a full-grown ovum it occupies a considerable area. This differentiation of color from the surrounding and gradually deepening yellow is owing to the increasing preponderance of albumino-oleaginous clear cells (Pl. 9, fig. 5c, *b*, 11c) around the Purkinjean vesicle, intermixed with the usually larger mesoblasted ones.[3] Again, as the egg comes to maturity, the yolk cells increase to an enormous size, (Pl. 9, fig. 11g, 11i,) their single yellow mesoblasts nearly fill them, and the waxy entoblasts gorge the mesoblasts. Thus, by the decrease of the clear space, and the filling up of the same by the darker and yellow mesoblasts and entoblasts, the whole egg gradually receives a deeper and more orange-colored hue, excepting, as we have said above, where the space around the Purkinjean vesicle is whitened by the greater predominance of cells with homogeneous contents and a white reflection.

At this time, too, the Purkinjean vesicle has lost its Wagnerian vesicles, and presents pretty uniform homogeneous contents, (Pl. 9, fig. 9c, 10c, 11b,) of a highly albuminous nature, so clear and dark as to give the surface of the egg the appearance of having a hole in it (Pl. 9, fig. 4–10; Pl. 9a, fig. 16, 18, 32, 32a). There is never, not even when the egg is matured, the least trace of a separation of a portion of the yolk around the Purkinjean vesicle, to form what is called, in the Bird's egg, the "cicatricula"; on the contrary, as we approach this region,

[1] According to Meckel von Hemsbach, Leuckart, Thompson, and others, the region in the vicinity of the Purkinjean vesicle of the Bird's egg is quite deficient in the "corpuscles" characteristic of the yellow yolk; the space thereabout and the canal leading to the centre of the yolk mass being occupied by bodies quite different from those exterior to them in the mass of vitelline substance. Yet, from the description of these authors, it would appear that the genetic connection of these bodies had not wholly escaped them; but that they have laid too much stress upon the extremes of a graduated modification, which is very similar to that which obtains in the egg of Testudinata.

[2] See the description of these cells, p. 474.

[3] The clusters of cells on the periphery of the enlarged Purkinjean vesicle, represented in fig. 5c and 11b, and marked *b* around fig. 5c, and 11c around fig. 11b, are meant to represent a part of the whitened yolk which surrounds these vesicles. As the reader may find some difficulty in tracing these references upon the plates, as the cells of the white area are represented on the edge of the figures referred to, which is their true position, a few more remarks are needed. In fig. 5c, the letter *b*, which designates these cells, may be seen on the margin of a cluster bordering on the left upper side of the Purkinjean vesicle which they surround. In the same manner are these cells represented in fig. 11c, as bordering the Purkinjean vesicle of fig. 11b, which they surround in the same manner as the smaller cells of the preceding figure.

the yolk cells present a smaller size and are less crowded, and clearer homogeneous cells mix in considerable numbers with them, so that really this is the most fluid part of the egg. From this point the yolk increases in density radiatingly, not only toward the periphery, but also in approaching the centre, which is not at all to be distinguished from the surrounding part by any sudden differentiation in its constituents.[1]

Although, from quite an early period, the cells around the Purkinjean vesicle are smaller than those which are more distant, yet the changes which take place in their mesoblasts and entoblasts are identical in all the yolk cells throughout the egg. The shape of the egg also gradually changes, with increasing size and age, from a flattened, more or less disciform, to a perfectly globular, figure, as it becomes more and more detached from the surface of the ovary, against which, in the earlier stages, it is very closely pressed.

Thus we see, that, from the beginning to the maturation of the ovarian egg, there is a constant dissimilarity between its two sides, one of which corresponds to the position of the Purkinjean vesicle, and the other to the opposite portion of the egg. The former contains within and around itself the extreme of albuminous concentration, and the latter the preponderance of oleaginous elements; yet, intermediate between the two sides there is a gradation, both in the proportionate size of the cellules and the relative amount of the above-named substances, which unite these extremes into one harmonious whole. How far this antagonism is carried out in the subsequent phases of the life of the egg will be more fully discussed in a future section; but this more we will say here, that, although we have had no opportunity for observing the intermediate steps between the maturation of the ovarian phase of the egg and the period of slightly advanced segmentation, we have still sufficient reason to assume that the same diversified portions mentioned above retain the same relative position[2] during the passage of the egg

[1] See note 1, p. 480.

[2] The clear space, observable in the egg of various animals just previous to segmentation, to which the name of "embryo cell" has been given, (see Thompson, l. c., p. 139,) from its supposed intimate connection with the formation of the germ, may be identical with the white area about the Purkinjean vesicle observed in Testudinata. We would take this opportunity to express the opinion, that very probably too much stress has thus far been laid upon the assumption that the Purkinjean vesicle performs a peculiar and exclusive function in reference to the formation of the so-called embryo cells; and, moreover, that the Purkinjean vesicle is not to be so definitely separated, as regards its essential elements, from the immediately juxtaposed substance of similar appearance, but should rather be looked upon as the crowning point of albuminous concentration, to which the opposite side of the egg stands in the reverse extreme of a highly oleaginous nature. A reference to the mode of origin of this vesicle shows this conclusively; for it is developed as a phase of secondary accession in the egg evolution, and not as the primary basis to a succeeding structure ever after retaining a significance of superior import, and leading, as some would have it, to its becoming in the end the essential element in

through the oviduct; nay, even that the ovarian egg is essentially the animal itself, developed to a certain degree of complication, which, if freed from the parent and cast into the world without passing through the last fecundation, finds itself in an unnatural element, and dies; but, if subjected to this vivifying impulse, is sustained for a much longer period. The antagonism observed between the elements of the egg, during its ovarian growth, is carried out further, during the whole life of the growing animal. The region at first occupied by the Purkinjean vesicle corresponds afterwards to the cerebro-spinal side of the embryo, whilst the vitelline region marks the nutritive or intestinal sphere of the new being.

However much the nature of the immature egg, as described above, may seem to identify it with the budding progeny of some animals, we are not prepared to admit a parallelism between the two; on the contrary, knowing the mode of origin of the former and the totally diverse derivation of the latter, we cannot see any common ground upon which the two processes could be identified.

We hope, in another volume, probably the next, fully to discuss this subject, in connection with another type of animals, the Hydroid Medusæ, in which these two modes of procreation obtain in the utmost diversity of combinations.

SECTION VI.

THE GRAAFIAN FOLLICLE, AND THE MEMBRANES OF THE EGG.

The Stroma. We have very little to say in regard to the mode of development of this layer, and can only offer a few suggestions, which may lead to further investigations hereafter. An egg hardly yet visible to the naked eye is covered by very faint traces of a semi-fibrous, semi-cellular, exceedingly transpar-

the genesis of the embryo. This mode of origin alone, we maintain, is sufficient to show that the very foundation upon which its importance is laid cannot be tenable, in this light. The Purkinjean vesicle, therefore, loses all its advocated claims to preponderance over the rest of the egg constituents; to say nothing of the fact that it takes no part in the building up of the blastoderm, excepting that its discharged contents may become absorbed in the endosmotic and exosmotic interchanges of substances between the oily yolk cells, and the albuminous matter in which they float. True enough, the region about this vesicle exhibits a specialized nature; it is there that the embryo first develops certain of its characteristics, previous to its further extension: but it does not follow, that, because the Purkinjean vesicle is situated thereabout, it is the basis of this evolution, or in any way causatively connected with it. On the contrary, its presence is itself rather the result of certain tendencies, for instance, the concentration of albumen in that direction; and its disappearance also is the consequence of the consummation of these tendencies.

ent layer, pressing closely upon the exterior of the "tunica granulosa," and apparently developing by the cohesion of the exterior cells of the latter[1] (Pl. 8, fig. 9). Not long after this, upon an egg just visible to the naked eye, this layer exhibits faint traces of being doubled, yet withal retains pretty nearly its pristine transparency (Pl. 8, fig. 12, *a*; Pl. 9a, fig. 13, *a*). Upon an egg one sixteenth of an inch in diameter its fibrous structure has become quite apparent (Pl. 9a, fig. 16, 16a, *a*); and another ovum one tenth of an inch in diameter is inclosed by a double membrane, the inner layer of which (Pl. 9a, fig. 18a, *a*) is as thick as the zona (fig. 18a, *e*).

On account of the appearance of bloodvessels in the stroma, at this time, by which the thickness of the latter is disguised, we can only say that it becomes a more loose, network-like tissue, the outer layer of which is very movable upon the inner. This is particularly noticeable in full-grown eggs. The bloodvessels of the stroma develop pretty uniformly over the whole of its extent, excepting a circular area at the most distal side, where they suddenly thin out into fine capillaries, anastomozing among themselves (Pl. 9, fig. 5, 7, 8, 9, 10; Pl. 9a, fig. 32). Just before the exclusion of the egg from the ovary at the breeding season, the bloodvessels become very much gorged, (Pl. 9a, fig. 32,) so that the larger eggs appear to be covered by an almost continuous blood-red layer. The bloodvessels, as they come up to this area, the region of the "cicatricula," suddenly bend upon themselves without diminishing their diameter, and commence their returning course. Now it is at this sudden bend that the capillaries which supply the cicatricula take their rise, and into this their retufn currents empty (Pl. 9a, fig. 32). After the exclusion of the egg, these vessels become paler, and are to all appearances fewer in number; they gradually disappear with the resorption of the corpus luteum.

The Tunica granulosa. In a former section[2] it has been shown, that, at the time of the formation of the egg, the cells of the Graafian follicles were not arranged in any particular manner in reference to the body which was developing among their interstices. By and by the egg has grown to such a size (Pl. 8, fig. 1, h^1; Pl. 9a, fig. 10) that the inclosing cells may be said to form an enveloping layer, although they have not changed in the least as regards their form; nor does this happen even when the egg has attained to a much larger size (Pl. 8, fig. 1, o^1; Pl. 9a, fig. 11). As we have before mentioned in passing, the cells of the follicle, around the younger eggs, are very transparent, of thin contour, with a nearly spherical shape, each containing a central, faint, and comparatively large mesoblast.

[1] See, below, p. 484.

[2] See Sect. 1, p. 454.

At a much later period, (Pl. 8, fig. 5, 9,) these cells begin to press against each other, and to assume a more or less polygonal shape; yet this change does not at all correspond to the age or size of the egg, but appears to exhibit a considerable amount of variation as to shape and magnitude, since in a follicle inclosing an ovum invisible to the naked eye (Pl. 8, 12, *b*; Pl. 9a, fig. 13, *b*, 13a) the cells are closely set against each other, whilst in another and much larger egg, visible without a lens, (Pl. 9a, fig. 12, 12b, 17, *c*,) there is but very little mutual crowding. In addition to their change in shape, the cells last mentioned have also undergone an internal alteration: a darkening of their walls, and a slight increase in the conspicuousness of the mesoblast (Pl. 8, fig. 5, 9; Pl. 9a, fig. 12b, 17, *c*).

An egg about twice the diameter of that represented in Pl. 9a, fig. 12, when brought under the microscope, has the appearance of being covered by a network with polygonal meshes. These meshes, when more magnified, are found to be large, mutually compressed cells, belonging to the innermost layer, or tunica granulosa, of the Graffian follicle. Their size has considerably increased, and the contents have become very hyaline, especially the large mesoblast, which it is very difficult to detect (Pl. 9a, fig. 14, 14a). Each mesoblast occupies about one third the diameter of its ectoblast; as usually, before and afterwards, it has a central position, and is remarkable for its thickness (Pl. 9a, fig. 14) when compared with its breadth. The external surface of these cells is more or less flattened next to the inner stratum (Pl. 9a, fig. 14, *a*) of the stroma, a feature more conspicuous still in older eggs.

When the egg has about one tenth of an inch in diameter, (Pl. 9a, fig. 18,) the exterior surface of these cells is closely pressed and flattened against the fibrous stroma (Pl. 9a, fig. 18a, *b*); and the cells themselves have become internally so transparent that even the mesoblast is not visible, except when brought out by reagents. This hemispherical shape, with their rounded surface next to the zona pellucida, they retain for the rest of the interovarian life of the egg (Pl. 9d, diagram, fig. 2, *b*). What further changes they undergo, after the egg has been expelled from their embrace, has not yet been investigated, and therefore the subject must be left for further research.

The Zona pellucida. Although the zona pellucida is developed later than the vitelline sac, yet, on account of its connection with the Graafian follicle, we think it proper to consider it first. The earliest appearance of the zona pellucida which we have noticed is seen at a time when the egg has already become visible to the naked eye (Pl. 9a, fig. 12); it is then represented by a layer of excessively hyaline, large, flat cells, (Pl. 9, *a*, fig. 12a and 17, *b*, *b'*,) resting on the outer surface of the yolk sac, and just within the tunica granulosa (*c*). For want of observations we can say nothing about the origin of these cells, excepting that, from their position, they must be developed from the Graafian follicle, and indicate, beyond the possibility of a doubt, that the zona, of which they are the constituents, is not a part of the yolk, but an envelope of the egg.[1]

In the next stage, in an egg about one sixteenth of an inch in diameter, we find the cells of the zona so pressed against each other that their outlines are not recognizable, (Pl. 9a, fig. 16, 16a, c,) and only a clear, thick band represents the presence of this membrane. Again: in an egg about one tenth of an inch in diameter, this layer is found much thickened and more conspicuous, by reason of the transverse striæ which extend from its outer to its inner contour (Pl. 9a, fig. 18, 18a, *e*). The nature of these striæ is readily demonstrable, by breaking up the zona; when it becomes evident that they are the outlines of columnar cells,[2] (Pl. 9a, fig. 19,) flattened in a direction opposite to that in which we found them in the beginning (Pl. 9a, fig. 17, b^1). At this age the zona is a very elastic and flexible yet tender layer, exhibiting a considerable degree of tenacity between the cells of which it is composed. This structure remains unchangeable for the rest of the interovarian life of the egg, (Pl. 9d, fig. 2, *c*,) as may be demonstrated by resorting to a full-grown ovum.[3]

Subsequently to the entrance of the egg into the oviduct, the zona would seem to be gradually resorbed, as the "investing membrane," developing close upon the surface and from the substance of the yolk, becomes more and more defined as a membrane, and takes the place of the former. At what period the zona disappears altogether it is not possible now to say; but, in some instances certainly, not till after the embryo has commenced to form its amnios, when it appears to be very thin, and, in addition to other characteristics, is remarkable for turning suddenly to a nacreous white upon the application of water. This latter peculiarity we have not noticed previously. At a later period it has not been possible to find the least trace of the zona, excepting perhaps a mere film lining the shell, as late as during the middle period of incubation.

The Vitelline Sac. In a previous section[4] we have already discussed the origin

[1] See, below, note 1, p. 486.

[2] Thompson, loc. cit., page 83, says he is inclined to believe that these striæ, as seen by Remak (Müller's Archiv, vol. 4, p. 252) in the ovum of the rabbit, do not depend on any structure of the zona itself, but rather on the markings produced by the adhesion of the pediculated cells of the tunica granulosa, which, under pressure, leave a radiated appearance on the zona; but we would ask, how are the cells of the tunica granulosa enabled to produce transverse striæ in the considerable thickness of such a membrane as this? We can hardly believe that these cells have such a far-reaching power.

[3] Dr. Martin Barry (Researches in Embryology, Phil. Trans., 1838, p. 316) says, "In the ovary of Birds, Amphibia, and Fishes, it is, I believe, allowed that there is no membrane formed external to the membrana vitelli," and denies that the zona pellucida ("Chorion," as he calls it, but in Phil. Trans., 1839, p. 310, he says "Zona,") has its parallel in other Vertebrata than the Mammalia.

[4] See Sect. 1 of this Chapter, p. 454–456. What

of this membrane, the primitive egg-cell wall, and have here only to speak of its permanence up to a certain period, (Pl. 9a, fig. 18, 18a, *c*,) when the egg has attained to a size of about one tenth of an inch in diameter, beyond which, very probably, its function is supplied by the already well developed zona pellucida, whilst it is gradually resorbed; at least, we have observed no trace of its existence after this time. Of its changes, from the time of its origin till its disappearance, little can be said of such a thin, apparently structureless membrane, beyond the mere notice of the gradual thickening and defining of its outline, till there is no doubt left of its perfect distinctness, as a layer, from the yolk which it incloses.[1]

The Embryonal Membrane.[2] On the surface of the yolk, in an egg hardly visible to the naked eye, there is a layer of minute, singly mesoblasted cells, (Pl. 8, fig. 12, *d*; Pl. 9a, fig. 13, *d*,) apparently not yet connected with each other. On account of their size, and of their color, which resembles that of the yolk in the intermediate neighborhood, it is no easy matter to recognize these cells at first sight; but when once seen, and their peculiarity noted, their presence may afterwards be readily detected by a practised eye. As to the mode of their origin, there appears to be but one explanation, which is, that they are peculiarly modified yolk cells. In confirmation of this explanation we may mention their outline, which as yet is thick,

is now called vitelline sac is the primitive cell wall of the primitive ovarian egg.

[1] Thompson (article *Ovum* in Cyclop. Anat. p. 78) compares the early yolk sac of Birds (which he hardly admits as a true *membrana vitelli*, notwithstanding Meckel's researches) to the zona pellucida of Mammals, (the true primary vitelline sac of these animals, interior to the zona, being totally ignored by him; see also p. 50, where he describes the zona as the original yolk sac, and the only one existing in Mammals,) and the secondary yolk sac (the true zona) to the tunica granulosa of viviparous Vertebrates. The secondary yolk sac, he infers, is derived from the cellular lining of the Graafian follicle; but, since at the same time he makes it merely the exterior stratum of a concentric series, the inner of which, he insists, become the true yellow yolk granules, (the primary yolk sac, zona pellucida, as he calls it, having disappeared by deliquescence,) it looks very much as if he had mistaken the development of the "membrana investiens" for that of the membrana vitelli. Again he says, (p. 78,) "the external edge of the layer of prismatic cells, the length of which is considerably increased, is now surrounded by a narrow, pellucid space inclosed by a double line, presenting the appearance as if a small part of the bases of these cells had been fused together in a homogeneous film." This, probably, is the true zona pellucida of Birds; he having failed to see the membrana vitelli, (already disappeared, as he thinks,) situated between it and the layer of prismatic cells, from which latter he supposes, but without direct research, that the "pellucid space," because of its traces of hexagonal markings, is an immediate development.

[2] Until more extensive investigations have proved the identity of this membrane with the "Keimblase" of Bischoff, or the "Umhüllungshaut" of Reichert, which is called "investing membrane" by some English writers, it seems best, in order to avoid confusion, to give it a distinct name. That of "embryonal membrane" appears the most acceptable and significant. It can hardly be an objection that it recalls the embryonic envelopes, for it is in the end more or less intimately connected with them.

their oily appearance, their separation from each other, and their position within the vitelline sac.[1] In an older egg, about one sixteenth of an inch in diameter, (Pl. 9a, fig. 16, 15,) their contents are granular, and the mesoblast very darkly and thickly outlined, evidently by reason of its oiliness, which, by its highly refracting powers, produces also a dark centre resembling, and no doubt often mistaken for, an entoblast. In an egg one tenth of an inch in diameter, these cells (Pl. 9a, fig. 20, 20a, *a*, *b*,) hardly differ from the last, excepting that their mesoblasts are less in size; an irregularity, according to age, noticed elsewhere in regard to the constituents of other membranes. In another egg of this size we have represented this membrane in profile, (fig. 18a, *c*,) as bounded by two lines, the outer being the original yolk membrane, and the inner the line of demarcation between the yolk and the membrane in question.

The manner in which the cells of this layer overlap each other, in an egg about one quarter of an inch in diameter, (Pl. 9a, fig. 21, 21a,) shows that they do not as yet all lie in one plane. Here their size, and also that of the mesoblast, is considerably increased. The latter has moreover a dot, the entoblast, in its centre, and in some instances two dots, with a corresponding elongation of the mesoblast, apparently indicating that a self-division is in progress, which, as will be seen hereafter, (Pl. 9a, fig. 27,) is finally accomplished. Upon opening the egg, this layer is found to have such a consistency as to restrain the yolk from spreading rapidly; and moreover it is recognizable by its much lighter color.

In a full-grown egg the cells of the embryonal membrane are considerably larger and more transparent than in the last egg, and exhibit the same double entoblasts (Pl. 9a, fig. 22a). By fixing the focus of the microscope at the horizon of their greatest diameter it will be seen that they are sharply polygonal, (fig. 22,) the broad light bands between them representing the thickness of two juxtaposed walls, the superficies of which are obscured by mutual fusion, and by the absence of refraction consequent upon the loss of curvature.

Thus far, the embryonal membrane has been traced in its development as a feature of the interovarian egg; whatever else may be said of it hereafter, refers to its more or less intimate connection with the changes of the embryonic envelopes, of which it becomes at least a prominent part, if not conspicuously an efficient member.

In an egg in which the cephalic hood has commenced to form, (Pl. 11, fig. 1, a^1,) the cells of this membrane (Pl. 9a, fig. 24) are very transparent, especially where they rest closely upon the back of the embryonal area; yet, excepting perhaps the slightly smaller size of the mesoblast and the apparent presence of a dot

[1] See note 1, p. 486.

within the highly refractive entoblast, they differ hardly at all, individually, from those of the mature ovarian egg (Pl. 9a, fig. 22). Considering their arrangement, however, we find that here they are all in one plane, forming only one stratum by their juxtaposition. By applying a magnifying power of eleven hundred diameters the mesoblasts and entoblasts are brought out more clearly and appreciably (Pl. 9a, fig. 24a): the former, the mesoblasts, appearing to be composed of a stratum of juxtaposed granular bodies; and the latter, the entoblasts, to contain in some instances simply a lateral, dot-like entosthoblast, such as could not be produced by any sort of refraction, and in others a hollow, vesicular entosthoblast. But the presence of entosthoblasts cannot be of great importance, since, as far as we have been able to see, they are no longer visible beyond this stage.

By the time that both the cephalic and caudal amniotic hoods are evident, (Pl. 11, fig. 2, a^1, a^2,) these cells have become excessively transparent, (Pl. 9a, fig. 25, 26, 29a, *b*, *b*,) so that it is almost impossible to recognize them, except by the most careful manipulation, unless they are brought out by a process of maceration in reagents, which it is by no means safe to do, since they are greatly distorted by it. They may be best seen in the area pellucida (Pl. 11, fig. 2, *c*,) without disturbing the neighboring layers, and in other regions by carefully removing the subjacent loose cells, or by folding a portion cut away so as to bring them into profile (Pl. 9a, fig. 29a, *b*, *b*). In the latter position their thickness may be seen to be considerable, and the superficial contour of each to be distinctly arched, the whole lying close against the germinal layer beneath them. By careful focussing, the mesoblasts may be shown to be attached to the arched surface of its cell, (Pl. 9a, fig. 29,) and so thin that it cannot be recognized in profile. Owing to their hyaline nature, the entoblasts were not recognized, although they were probably present, since in an older stage (Pl. 9a, fig. 23) they were detected, under more favorable circumstances. In some instances all trace of mesoblasts, entoblasts, and entosthoblasts, was lost (Pl. 9a, fig. 26); but their presence was proved by reagents. The figure just quoted represents the equatorial region of the cells below the horizon of the mesoblasts, so that the double thickness of the walls is shown. Were it not for the presence of granules within the cells, in the profile view, (Pl. 9a, fig. 29, *b*, *b*,) we should suspect that those seen from the outside (Pl. 9a, fig. 25) were components of the layer below them. By this time the embryonal membrane has already such a consistency that it may be lifted up separately from the layer it covers; but, on account of the distortion of its cells, it is not safe to study it after such a process.

At a little later period, when the "primitive furrow" (Pl. 11, fig. 3, *b*) has commenced to form, the mesoblasts (Pl. 9a, fig. 23) contain faint entoblasts, which at first appear to be the result of an optical expression, oftentimes noticeable in clear cells; but here the lateral position of some of them, and their variable size, testify to their reality, whilst the application of water brings them out more strongly. Our figure gives a good idea of their appearance under this influence.

We have been fortunate enough to recognize these cells in an egg which had already been laid as long as eighteen days, and in it they were seen undergoing self-division (Pl. 9a, fig. 27). A greater part of the mesoblasts were double, and more or less separated from each other; and here and there were those which, partially constricted, already contained two entoblasts. The size of these double mesoblasts is exactly that which would follow the division of a single mesoblast like those observed in the younger phases of the same kind of cells. The same transparency and angularity as we have formerly observed prevail here, so that their identity is beyond question.

A longitudinal section of an embryo, of about the age of that represented in Pl. 12, fig. 1, shows that this layer (Pl. 9d, fig. 1, ...) follows closely every folding and bending of the germinal layer, (Pl. 9d, fig. *a*, a^1, a^2, a^5, and a^6,) whether it be over the curved back of the "embryo," or into the furrow which forms the incipient spinal tube, (Pl. 24, fig. 13a, *c*, *c*,) or close to its now very much depressed head, or backwards and upwards again with the folds of the amnios.

In later periods, when the amnios is closed over, the embryonal membrane forms an inner lining (Pl. 9e, fig. 7, ...) to the amniotic sac; a portion is also inclosed within the spinal tube, as its approaching edges unite above; and, in a transverse section of this tube, totally shut, a thin film (Pl. 9e, fig. 6, ...) was apparent, but evidently undergoing a change, no doubt tending to resorption. That portion of it, however, which surrounds the whole yolk, remains distinct until the young animal is hatched; but in these latter days it is evidently decomposing, (Pl. 9a, fig. 31, *a*, 31a, *a*,) at least its cells were more or less separated from each other, and their walls ragged, as well as those of the mesoblasts. In some cells two mesoblasts were still visible.

SECTION VII.

FECUNDATION.

Ever since I have known that our Turtles lay only once a year, I have been struck with the fact that the ovary nevertheless contains eggs of very different sizes. I was led by this observation to inquire into the duration of the growth of the ovarian eggs, when I further noticed that these eggs appear in well-marked sets of different sizes, each set being equal in number to the average number of eggs laid by the species under observation. It thus became evident that the eggs require more than one year for their full development. Once upon this track, it appeared practicable to determine how long a period this growth embraces; for, as soon as it could be ascertained how many eggs different species of Turtles lay, there was a standard of comparison obtained for the investigation of the ovaries; and, as I early learned that the species most common about Cambridge exhibit marked differences in that respect, I selected these species for my first studies. Chrysemys picta lays always between five and seven eggs. I have never observed as few as four, and only occasionally eight. Nanemys guttata lays generally two or three; I have only once or twice found four eggs in its nest, and three times in its ovary. There was therefore no chance of making any mistake, when comparing the number of their ovarian eggs with that of the eggs they lay, after I had ascertained that a few weeks before the breeding season there are the same numbers of mature eggs to be found in the ovary as these species usually lay in the spring. I felt still greater confidence in the possibility of coming to precise results, after I had found again and again the very same number of eggs in the oviduct,[1] and noticed that at that time another set of eggs could be readily distinguished, of the same number as the larger eggs left in the ovary. Indeed, the difference between this largest set of ovarian eggs and the smaller ones is so great, even at the time when the eggs about to be laid are still in the oviduct, that they are distinguished at the first glance; for, though they have unquestionably to remain another year in the ovary, they are already nearly as large in diameter as those which have just left it.

With a knowledge of these facts, it was easy to arrive at a full understanding of the normal periodicity in the growth of the ovarian eggs. It soon became plain, that shortly before the period of laying there were not only two, but as many as four, distinct sets of eggs in every ovary; and that, after the largest set had been laid, a new small set was started from among the innumerable smallest eggs of variable size. It now seemed that a single question remained to be answered. What is the age at which the Turtle discloses for the first time such differences between its eggs? Upon opening large numbers of young Chrysemys picta[2] it was ascertained, that, up to their seventh year, the ovary contains only eggs of very small size, not distinguishable into sets; but that with

[1] It has already been stated above that the eggs of one ovary are not necessarily received into the oviduct of the same side of the animal, but may be taken up by the fallopian tube of the opposite side. See Part II., Ch. 1, Sect. 13, p. 288.

[2] Comp. Part II., Ch. 1, Sect. 14, p. 292, where the most prominent characters of this species and the differences in its size, in successive years, are given approximately, for the first twenty-five years of its existence.

every succeeding year there appears in that organ a larger and larger set of eggs, each set made up of the usual average number of eggs which this species lays, so that specimens eleven years old, for the first time, contain mature eggs, ready to be laid in the spring.

Now another question arose, When are the eggs fecundated? Field observations soon taught me that this species copulates before it is eleven years old; I have even seen those that were not over seven years old already performing the act, though I have never seen any in copulation younger than these. Thus it appears that the first copulation coincides with a new development of the eggs, in consequence of which, a certain number of them, equal to that which the species lays, acquire a larger size, and go on growing for four successive years before they are laid, whilst a new set is started every year, at the period of copulation in the spring, enabling this species to lay annually from five to seven eggs, after it has reached its eleventh year.

The question was then naturally suggested, whether fecundation is the result of the first act of copulation, or of the second, the third, or the last; or whether the first copulation only determines the further growth of a certain number of eggs, which require a series of successive fecundations to undergo their final development. The second alternative appears the more probable when it is remembered that Turtles were observed[1] which did not lay their eggs as usual, though the yolk had undergone all the regular changes through which it passes, up to the time the egg has entered the oviducts. This is another fact which tends to prove that fecundation is a successive act. Though Turtles lay only once every year, soon after the period of copulation in the spring, copulation itself does not take place once merely, every year, as in all the animals known to bring forth young once annually; it is repeated a second time, every year, in the autumn, shortly before the Turtles retire to their winter-quarters;[2] and this takes place without apparent connection with any marked change in the growth of the egg at that season. So, in Turtles, fecundation does not appear to be an instantaneous act, resulting from one successful connection of the sexes, as it is with most animals. The facts related above show, on the contrary, that, in Turtles, a repetition of the act, twice every year, for four successive years, is necessary to determine the final development of a new individual, which may be accomplished in other animals by a single copulation.

It may be suggested, that, by an investigation of the spermatic particles, additional light would be thrown upon these remarkable circumstances. But such investigations present greater difficulties in these animals than could be supposed

[1] See below, Ch. 2, Sect. 4.

[2] Comp. Part II., Ch. 1, Sect. 11, p. 284.

at first; and notwithstanding the most diligent search, my efforts to trace the spermatic particles through the oviduct, as high up as the ovarian eggs, have been unsuccessful. Turtles do not copulate in confinement; and those which I could catch in coitu in their native haunts have only exhibited spermatic particles in the oviduct. I have, still less, been able to trace the sperm into the egg itself. Indeed, there is no micropyle in the egg of Turtles; and I must confess that I have not yet seen the first fact which could lead me to admit that the spermatic particles penetrate into the egg. I am therefore obliged to abstain from expressing any decided opinion upon the question of the penetration of the spermatic particles into the egg, which has of late attracted so much attention among embryologists. I can only say, that, notwithstanding the high authority upon which it is asserted as a fact that the spermatic particles do pass into the substance of the egg through a definite aperture of its envelope, I am still rather inclined to doubt it.

The aperture observed in the outer membrane of the egg, which has been called micropyle, has always appeared to me to be the result of the separation of the sac in which the egg is developed, and by no means to pass through the vitelline sac. Without the most careful examination it is not possible to perceive how complicated the sac is, in which the egg is inclosed; and I suspect that a kind of Graafian follicle, which in many animals drops from the ovary with the egg, has frequently been mistaken for a vitelline membrane. I believe, further, that the scar resulting from the separation of that follicle forms the opening called micropyle, and that this opening does not traverse the vitelline membrane. In Turtles the perforated appearance of the yolk sac arises from the presence of the Purkinjean vesicle near the surface of the yolk, and not from the existence of a real hole. (Comp. p. 456, 459, and 460.) After what has been said above of the lateral origin of the Purkinjean vesicle, it is superfluous to insist upon the incorrectness of the view of those who would ascribe its superficial position to the influence of fecundation. It is formed in that position, and preserves it as long as it exists.

CHAPTER SECOND.

DEVELOPMENT OF THE EMBRYO FROM THE TIME THE EGG LEAVES THE OVARY TO THAT OF THE HATCHING OF THE YOUNG.

SECTION I.

THE LAYING OF THE EGGS.

To tell American students that little is known of the habits of Turtles, the laying of their eggs, the growth of their young, etc., would perhaps excite a smile in those who, as boys, have been in the habit of collecting Turtles' eggs; egg-hunting being an occupation of which boys are fond all the world over. Yet so it is: what every inhabitant of the country may have seen again and again has not yet been collected in scientific works. I have however availed myself largely of the information circulated from hearsay throughout the community, as it was the best preparation for a thorough study of the Embryology of these animals. Guided by these reports, I could avail myself of the best opportunities for direct investigation, everywhere and at all times. But, though this be the case throughout the United States, it is nevertheless true that this information is nowhere recorded, and that the book-learned are ignorant of what every farmer, living by the side of our ponds and marshes, has known from childhood. I cannot, on that account, allow this opportunity to pass without emphatically calling attention to a point which is of the utmost importance for the farther progress of science in this country, where a desirable object is hardly made known, before its execution is taken into consideration. Had our public and private libraries been better supplied, and arranged with more system, so that their deficiencies in some points might have been as apparent as their completeness in others, the omission to which I have just alluded would certainly have been corrected long ago, and I should have been too late with the results of my investigations upon this subject, now published in this volume. And it should be remembered, that a well-marked blank in a library may be as suggestive as a well-filled shelf, and may induce the young naturalist to take up some branch of study which has been neglected. For my own part, I well recollect, that, on my first visit to the University of Heidelberg,[1] at the age of nineteen, on asking the librarian to show me all that had been published upon the subject of Fishes, he pointed me to a meagre shelf, and on examining its contents I found that many important facts, with which my youthful rambles and my early love of Natural History had made me familiar, were unknown to naturalists. "And is this all?" was my repeated inquiry. But the librarian, as well as the professor of Zoölogy, assured me that these volumes contained all that was then known to the scientific world on the subject of Fishes. Afterwards, I mentioned to Professor Leuckart the facts which observation had taught me with respect to the seasons of spawning, the mode of growth, the geographical distribution, and the habits of the Fishes of Switzerland; and, when I found that they were new and interesting to him, I no longer doubted as to the field in which to commence my labors. That blank in the well-ordered library taught me more, as to the scientific path which I should choose, than shelves crowded with volumes could have done. I mention this anecdote merely to show the importance of systematic arrangement in our libraries, in order that our young students may perceive at once in what departments their investigations are most needed. Otherwise, much time may be lost by toiling in already well-ploughed fields, and valuable facts may be left unrecorded.

For the same reason I would urge upon the consideration of those interested in the progress of science in America the value to the student of well-stored museums, and especially of local collections containing series of specimens of every species of animals, plants, minerals, rocks, and fossils found in the vicinity of every school throughout the country, with precise indications respecting their origin.[2] With reference to this last topic, too much cannot be said of the impor-

[1] This was in the spring of the year 1826, two years before the publication of the first volume of the great "Histoire naturelle des Poissons" by Cuvier and Valenciennes.

[2] It is a great mistake to suppose that large museums are necessary for the study of Natural History, and that show specimens from distant countries add much to the interest of a scientific collection. I deliberately assert, that there is not a school-house in the United States, in the immediate vicinity of which it would not be easy to make, in a few years, a collection of native specimens sufficient to illustrate the fundamental principles of any branch of Natural History. Nay, it is not too much to add, that such collections would contribute greatly to the advancement of science, if simple catalogues of their contents were published from time to time. I am satisfied, from my own experience, that every such collection could, in

tance of correct dates and labels for every specimen. A most valuable collection may be made almost useless from want of attention to these details; whereas if every contributor to public or private museums would furnish precise information respecting the origin of the specimens he has collected, he would confer a real service upon science. Every specimen should be marked with the exact date and place at which it was found, otherwise it may be worthless for purposes of comparison with other specimens. It would not be difficult to show how important are these apparently trifling details. One example may suffice. Thousands of specimens of the Blind Fish of the Mammoth Cave have been brought home by visitors of that interesting locality, and are now scattered throughout the country. They have been examined again and again by naturalists; but to this day the period at which they spawn has remained unknown, even though eggs have been observed in their ovary in an advanced state of development. Had the collectors marked the time at which such specimens were caught, we should know, from that observation alone, what is their spawning season. And so it is with every kind of specimens; without accurate dates we shall learn little from them, of what they might teach us, if they were properly labelled.

With reference to the subject of Turtles, now under consideration, the cause of the discrepancy between the knowledge of the learned and of the field observer lies in the circumstance, that, in the Old World, no Turtles are to be found in the immediate vicinity of the great centres of study, and that most of the information collected upon these animals has been recorded from the casual observations of travellers. In this estimation I do not, of course, include the investigations made upon their structure, which may very well be traced and completed from specimens preserved in alcohol; as every naturalist knows that one of the master-works upon Comparative Anatomy is that of Bojanus upon the Anatomy of the fresh-water Turtle of Eastern Europe.[1] Rathke has also published as full an Embryology of that species[2] as the circumstances under which it was prepared would allow, a monograph, which, with his many other embryological researches, has won for him a place in that constellation of eminent writers whose studies have made Embryology what it now is. But it is felt, on almost every page of his work, that he labored under a scarcity of materials which constantly impeded his progress. As I can plead no such difficulties for the imperfections which my present

less than ten years, be made worthy of a careful examination by even the most critical professional naturalists, and would afford to the teachers and pupils a source of ever new interest in their walks, and of ever increasing extension of their knowledge, and ability to observe. In Massachusetts a very good beginning has already been made, in several schools; and most successfully by Mr. J. W. P. Jenks, in Middleboro'.

[1] BOJANUS (L.), Anatome Testudinis Europaeæ, Vilna and Leip., fig. 1819–21, vol. fol.

[2] RATHKE (H.), Ueber die Entwickelung der Schildkröten, Braunschweig, 1848, 1 vol. 4to.

work undoubtedly still contains, I feel the more the responsibility I have assumed, in undertaking to write anew the Embryology of that order of Reptiles. But, if I cannot expect to exhaust the subject, I may at least hope to show how instructive this field may become for the American student, and how important it is for science in general. Every European embryologist must envy the opportunities our naturalists have in this respect; and it is the duty of those who possess such advantages to supply fully and freely any additional information which a thorough comparison of the structure and embryology of the different genera and families of our Turtles may afford, and which is not already included in the following pages.

The age at which Turtles begin to lay has been ascertained, with sufficient precision, only for one species, our common Chrysemys picta. By the help of a series of specimens, from those just born up to adult ones, it was possible to trace the progress of growth of the ovarian eggs till they were ready to drop into the oviduct; and thus the fact was elicited, that the eggs do not begin to differ in size among each other by any readily appreciable amount until the seventh year, and that the process of reproduction by laying is not commenced before the eleventh year. Several other genera of this and other families were examined in reference to this point, but for want of materials the investigation was not carried on so extensively nor with so much precision as with Chrysemys picta; yet enough has been seen to warrant the assumption, that from the eleventh to the fourteenth year[1] is about the age at which most, if not all, our native fresh-water Turtles lay their eggs for the first time.

Again: the time of the year at which they lay is the same for both the northern and the southern species, without reference to physical differences, such as temperature, moisture, etc., or climate in general. Graptemys LeSueurii, which lays as early as the first of June, gives the earliest instance of incubation in the year, and this is a western and south-western species. Chelydra serpentina, the species most widely distributed in the United States, at the North lays as early as the tenth of June, and continues to do so till the twenty-fifth: some individuals disposing of their burden as early as the first date, and others as late as the latter.

[1] A careful comparison of the relative distance of the successive lines of growth of the scales may satisfy any one that the Turtles grow more rapidly during the first ten or twelve years of their life; and that after the twelfth or fourteenth year the rate of increase is considerably diminished. From the facts observed in our little Chrysemys picta it is certain that this is also the period at which they begin to lay. There exists, no doubt, some difference between different families; but, judging from the change in the rate of increase after the twelfth or fourteenth year in different species, there can be no doubt that this is a critical period in the life of all the scaly fresh-water and land Testudinata, and Chrysemys picta shows that this is connected with the period of their first reproduction.

No one of our Turtles makes more than a single nest. They deposit all their eggs at once. Chrysemys picta has an almost identical period of incubation with Chelydra serpentina, namely, from the eleventh to the twenty-first of June, and even to the twenty-fifth; since eggs were found in the oviduct, as late as the latter date, in a Turtle picked up in the field and opened at once. Thalassochelys Caouana, a southern marine species, lays as late as the fourth of June. Later than the dates mentioned above, no Turtle has been known to lay, except in confinement, where the time of laying is occasionally delayed for a whole month, namely, till the eighteenth and twentieth of July; and yet, in very many instances, the embryo of such eggs was alive, and continued its normal development. A Cinosternum pennsylvanicum, kept confined, did not lay till the seventh of October, and then only brought forth a single egg, which was in all probability not fecundated, judging from the unnatural appearance of the yolk.

The beginning of the development of the embryo, in the ordinary acceptation of the term, coincides neither with the act of fecundation nor with the laying of the eggs. But, even if we should extend the meaning of the term embryo to the whole body of the egg, there is no appreciable connection, in Turtles, between its developing and the acts just alluded to, such as is known to exist in other animals. The egg is formed, and its development goes on to a certain point, long before the first copulation takes place. After this it continues to increase in size and to undergo a series of internal changes, during several successive years, before segmentation takes place; and, though this process follows the last connection of the sexes which precedes the laying of the eggs, it is hardly legitimate to ascribe it to that act, since copulation has been repeated again and again years before segmentation introduced another phase in the development of the yolk, and eggs were found in which segmentation had begun, though they were not fecundated. It seems to me more concordant with the facts observed to infer that fecundation is another of those organic impulses under which the development of the egg, begun without it, is now impelled into new phases, concomitant with this act, but not absolutely initiated by it. The autumnal copulation, which thus far has not even been found to coincide with any particular movement in the growth of the egg, certainly justifies such a view. But, though I would insist upon this interpretation of the facts, as observed in Turtles, it does not follow, that, in other animals, the influence of fecundation is not more directly connected with the changes the eggs undergo. In this respect again every type must be investigated for itself, before any general theory of fecundation can be attained. The only fact relating to Turtles which remains unquestionable in this connection, is, that the eggs are still in the ovary when the last copulation takes place, but soon afterwards pass into the oviduct.

It is not easy to ascertain the length of time during which the eggs remain in the oviduct after they have escaped from the ovary; from want of direct observation it remains a matter of conjecture. Referring to the tables[1] inserted

[1] The observations recorded here were chiefly made with the view of ascertaining how long the eggs remain in the oviduct, and also the time of laying. Hundreds of Turtles were opened besides, for the purpose of ascertaining the average number of eggs which different species lay, and also to trace the passage of the eggs from the ovary of one side to the oviduct of the other side; but the facts ascertained in that way were not tabulated, and are simply mentioned in the text. The queries indicate simply that the eggs were not counted.

CHELYDRA SERPENTINA.

Date.	Ovaries.		Oviducts.		Laid.	Remarks.
	Right.	Left.	Right.	Left.		
June 10, '55	—	—	—	—	laid	
June 12, '54	—	—	40*	—	—	In confinement.
June 13, '55	—	—	—	—	laid	
June 13, '55	—	—	—	—	laid	
June 15, '54	—	—	80*	—	—	Cicatrices, 21 in the left and 15 in the right ovary. In confinement.
June 18, '55	—	—	—	—	laid	
June 18, '55	—	—	71*	—	—	Taken from two animals.
June 19, '55	—	—	?	—	—	Out of seven animals opened, two had not yet laid.
June 20, '55	—	—	—	—	—	This was opened July 20, and found to contain eggs. See that date.
June 20, '55	—	—	—	—	laid	
June 21, '55	—	—	—	—	laid	
June 22, '54	—	—	—	—	laid	In confinement.
June 23, '54	—	—	—	—	laid	In confinement.
June 28, '55	—	—	—	—	laid	
June 28, '54	—	—	—	—	laid	In confinement.
June 25, '55	—	—	—	—	laid	Seen laying, but eggs not collected.
July 20, '55	—	—	?	—	—	Embryos alive. In confinement.

CINOSTERNUM PENNSYLVANICUM.

Date.	Ovaries.		Oviducts.		Laid.	Remarks.
	Right.	Left.	Right.	Left.		
July 3, '56	—	—	4*	—	—	All specimens of this species were in confinem'nt.
July 30, '55	3	—	1	—	—	Three of the eggs just ready to enter the oviduct.
"	—	—	1	2	—	
"	1	1	—	—	—	
"	2	1	—	—	—	
"	2	—	—	1	—	Two of the eggs just ready to enter the oviduct.
Oct. 7, '56	—	—	—	—	laid	Probably not fecundated. No embryo visible.

OZOTHECA ODORATA.

Date.	Ovaries.		Oviducts.		Laid.	Remarks.
	Right.	Left.	Right.	Left.		
June 5, '54	—	—	3	3	—	In confinement.
June 7, '54	—	—	2	2	—	" "
June 28, '55	—	—	—	—	laid	Three eggs.
July 9, '55	—	—	—	—	laid	In confinement.
July 10, '55	—	—	—	—	laid	" "

CHRYSEMYS PICTA.

Date.	Ovaries.		Oviducts.		Laid.	Remarks.
	Right.	Left.	Right.	Left.		
May 13, '54	4	2	—	—	—	In confinement.
May 15, '54	3	2	—	—	—	" "
May 16, '54	2	3	—	—	—	" "
May 20, '54	3	2	—	—	—	" "
June 3, '53	—	—	7*	—	—	" " One, shell soft.
June 11, '55	—	—	—	—	laid	In confinement.
June 14, '55	—	—	—	—	laid	" "
June 16, '55	—	—	—	—	laid	" "
June 20, '55	—	—	—	—	laid	" "
June 21, '55	—	—	—	—	laid	" "
June 21, '52	7*	—	—	—	—	In confinement. Next year's brood.
June 26, '55	—	—	?	—	—	Opened as soon as caught.

GRAPTEMYS LESUEURII.

Date.	Ovaries.		Oviducts.		Laid.	Remarks.
	Right.	Left.	Right.	Left.		
June 1, '56	—	—	—	—	laid	Natchez, Miss.

PTYCHEMYS CONCINNA (Floridana.)

Date.	Ovaries.		Oviducts.		Laid.	Remarks.
	Right.	Left.	Right.	Left.		
July 12, '56	—	—	6	6	—	In confinement. Natchez.

MALACOCLEMMYS PALUSTRIS.

Date.	Ovaries.		Oviducts.		Laid.	Remarks.
	Right.	Left.	Right.	Left.		
July 2, '55	—	—	—	—	laid	In confinement.
July 3, '55	—	—	—	—	laid	" "
July 12, '56	—	—	3	2	—	" "

below among the foot notes, for the times of laying, which indicate also when the eggs were found in the oviducts and when in the ovary, it may be possible to form some idea of the difficulty which the solution of this problem presents, when we see, that, for instance, Cinosternum pennsylvanicum in one case had eggs in the oviduct by July 3, whilst in another they were still in the ovary as late as July 30, and in still another of the latter date they were partly in the ovary and partly in the oviduct. Again: on the 21st of June, 1856, six specimens of Nanemys guttata were opened, and all found to have already laid; whilst on the 25th of June, 1855, this same species had not finished depositing its eggs; thus showing nearly a week's variation, no inconsiderable amount of time when we reflect, that, with this species, the laying season lasts but a week. This observation loses much of its importance, however, from the fact that it relates to broods laid in two different years.

EMYS MELEAGRIS.

Date.	Ovaries.		Oviducts.		Laid.	Remarks.
	Right.	Left.	Right.	Left.		
June 30, '54	—	—	4	5	—	In confinement.
July 17, '55	4	3	—	—	—	Next year's brood.

NANEMYS GUTTATA.

Date.	Ovaries.		Oviducts.		Laid.	Remarks.
	Right.	Left.	Right.	Left.		
May 8, '54	4	0	—	—	—	In confinement.
May 12, '54	2	0	—	—	—	" "
May 19, '54	2	2	—	—	—	" "
May 28, '54	3	1	—	—	—	" "
May 30, '54	—	—	2	1	—	" "
May 31, '54	2	1	—	—	—	" "
June 3, '54	—	—	1	2	—	" " Shell thin, soft.
June 8, '54	—	—	2	1	—	In confinement.
June 20, '55	—	—	—	—	laid	First date of laying.
June 21, '53	1	2	—	—	—	Next year's brood. The cicatrices on the ovary fresh.
"	1	0	—	—	—	
"	1	1	—	—	—	
"	1	2	—	—	—	
"	1	2	—	—	—	
"	1	0	—	—	—	
June 21, '56	—	—	—	—	laid	
June 26, '55	—	—	3*	—	—	Five Turtles opened; and all but one had laid.
June 26, '62	—	—	2	—	—	In confinement.
June 27, '53	1	2	—	—	—	Next year's brood. The cicatrice fresh.
June 29, '53	0	1	—	—	—	
"	1	0	—	—	—	"
"	1	0	—	—	—	"
"	2	0	—	—	—	"
"	1	0	—	—	—	"
"	0	1	—	—	—	"
July 9, '62	—	—	—	—	laid	In conf'nt. Embryo alive.
July 10, '62	—	—	—	—	laid	" "
July 11, '62	—	—	—	—	laid	" "
July 13, '62	—	—	—	—	laid	" "
July 18, '62	—	—	—	—	laid	" "

GLYPTEMYS INSCULPTA.

Date.	Ovaries.		Oviducts.		Laid.	Remarks.
	Right.	Left.	Right.	Left.		
May 3, '54	5	2	—	—	—	All the specimens of this species were kept in confinement, but not till after fecundation.
May 5, '54	4	2	—	—	—	
May 9, '54	4	0	—	—	—	
May 11, '54	3	3	—	—	—	
May 13, '54	3	4	—	—	—	
May 17, '54	—	—	1	2	—	No shell; animal young
May 18, '54	—	—	2	5	—	No shell.
May 20, '54	—	—	4	2	—	Shell soft.
May 23, '54	—	—	3	4	—	
May 27, '54	—	—	3	4	—	Shell soft; yolk segment'g.
May 28, '54	—	—	4	3	—	Yolk segmenting.
May 29, '54	—	—	4	2	—	

CISTUDO VIRGINEA.

Date.	Ovaries.		Oviducts.		Laid.	Remarks.
	Right.	Left.	Right.	Left.		
June 5, '54	—	—	2	3	—	Rather soft shell.
June 6, '54	2	2	—	—	—	In confinement.
June 25, '55	—	—	6*	—	—	Opened as soon as caught.
June 30, '54	—	—	3	2	—	In confinement.

XEROBATES CAROLINUS.

Date.	Ovaries.		Oviducts.		Laid.	Remarks.
	Right.	Left.	Right.	Left.		
June.	—	—	—	—	lays.	In New Orleans.

The * * mark the eggs the position of which, on the right or left side, was not noticed.

Now, unless one spends day after day and week after week in the fields in the neighborhood of the breeding grounds and catches each day a great number of Turtles of different species, in order to ascertain the presence of eggs in the oviducts, (as may very readily and confidently be done by inserting the finger between the shield and the plastron, just in front of the hind legs,) and then having marked them lets them go again to remain free and in a natural and untrammelled state until they can be taken up again perhaps within the next few hours or the next day, it is utterly impossible to determine when the eggs enter the oviduct, and how long they remain in this organ. Although we have seen many Turtles laying their eggs in confinement in a large yard where they were kept well fed and furnished with plenty of water, which is very essential to some species, and although these eggs developed their embryos, still they were always retarded, both as to the time of their being laid, and to the advancement of the young itself. By reference to the tables,[1] it will be seen that in two instances the eggs of Nanemys guttata and of Chelydra serpentina were retained in the oviduct nearly a whole month beyond the usual time of laying, in consequence of the confinement of these animals. The former having dug, as usually, a hole with its hind legs, at last dropped its progeny into the excavation, and covered the same so as to leave no trace of its operations; but the latter was opened, and found still retaining its brood.

As to the time of the day at which Turtles lay, there have been not more than three different species of so many distinct genera observed throughout the laying season; but, as a great many were seen always laying in the same part of the day, there can be no doubt that different species lay regularly at different times. Chrysemys picta and Nanemys guttata deposit their eggs in the evening, from six to half-past eight o'clock, and Chelydra serpentina in the morning, from four to twelve midday. Ozotheca odorata was seen laying but once, namely, at half-past eight in the evening.

In this connection it will be most proper to give some account of the kind of nests which these animals make, and of their manner of proceeding in the formation of the same. We have already alluded briefly to the laying of one species, (Nanemys guttata,) in confinement; but would say in addition, that this species, as well as Chrysemys picta, digs a perpendicular hole, whereas Chelydra serpentina excavates at first directly downwards and then laterally, so that the widest part of the hole, in which the eggs are deposited, is on one side of the external opening of the nest. Hence a stick thrust straight into the mouth of the nest would not touch the eggs, which are laid in the lateral dilatation of the

[1] See p. 498 and 499.

excavation. The fact, that these animals oftentimes dig several holes before selecting one for deposit, shows that they exercise a discrimination with regard to the fitness or unfitness of these several spots for the encouragement and rapid development of their young. When engaged in digging or laying, notwithstanding their habitual shyness at other times, they seem utterly unconscious of any intruder, but proceed in their occupation till it is finished, and then, trampling down and smoothing over the earth, so that when dry the place of the nest may not be noticeable, leave the spot and disappear among their usual haunts.

SECTION II.

DEPOSITION OF THE ALBUMEN AND FORMATION OF THE SHELL.

Before proceeding to describe the successive deposition of the albumen and shell around the yolk, a few words in reference to the functions of the various regions of the organ in which these deposits take place, will not be inappropriate. At the time of breeding, the bloodvessels of the ovary are unusually full, as if gorged with blood; and the black pigment cells so much increased, that the fold of the mesentery, to which the ovary is suspended, appears blackish, and black streaks accompany and overlie each bloodvessel[1] (Pl. 9b, fig. 9, 9a). Though numerous Turtles were opened from day to day, at the time when the eggs were passing from the ovary into the oviduct, (fig. 10,) yet so rapidly does this process go on, that not only was it impossible to catch the egg dropping from the one and entering the other, but even to find a single egg in or near the anterior part of the last-named organ. In one instance, however, the Fallopian tube was found in a state of turgescence, immediately after fecundation, and the trumpet gaping, as if open to receive the eggs dropping from the ovary. In all cases where the eggs had entered the oviduct, (fig. 11,) they were found in its lower part, some with shells, and others without this covering, and again a few with but little albumen around them. This we might almost have conjectured, had the thin, semitransparent nature of the pavilion and the immediate neighboring portion of the oviduct been considered from this point of view.

However, there need be no doubt now that at least one half, if not more, of the oviduct serves for just what its name indicates, merely to conduct the

[1] It will be shown in another connection, that the formation of pigment cells precedes everywhere the appearance of bloodvessels, and stands in direct relation to their formation.

eggs from the embrace of the ovary to the last third of its own channel, there to be endowed with an albuminous and calcareous covering, and withal to assume the shape peculiar to each species. In réference to the shape of the eggs of various genera, it is important to mention that they vary greatly in form, and that their outline does not answer to the prevalent theory that their passage through the narrow channel of the oviduct gives them their form, since we have those which are perfectly spherical, and yet sustain as great a lateral pressure from the embracing walls of the shell-forming conduit as those which are more or less oval. We need therefore adduce nothing more against this mechanical theory beyond the statement of such an obviously conflicting fact as the one just mentioned. We would, however, refer to the plastic power which gives to the embryo its typical form while it floats in the midst of a uniformly pressing fluid, in order to answer the question as to what renders some eggs almost cylindrical, others oval, and those of certain species more or less curved, approaching even to a kidney shape, whilst others are broadly oval, and finally, some perfectly spherical.

Since no eggs were found in the oviduct before the shell membrane had already been deposited, at least partially, it might be presumed as a matter of course that the albumen also had already taken its place around the yolk. This supposition is negatived, however, by the occurrence of eggs, observed especially in one well marked instance in Glyptemys insculpta, which formed a series of five in one oviduct, situated at the extreme posterior end of that organ, and close to one another, presenting just as many different grades of albumen and shell-lining deposit. The albumen was thicker and the shell lining more opaque for each successively more posterior egg, showing at a glance that not only the albumen, but the shell lining, was depositing at one and the same point of the oviduct; and moreover that the albumen, in order to reach its destined position, must filtrate through the meshes of the fibrous shell lining. There is no disputing this fact, which readily proves the normality of another single case which we have noticed, showing a still greater disparity between the amount of albumen, and the shell lining by which it was covered. The egg in question was found in company with another, in the right oviduct of the same animal; it was covered by a shell lining as thick and opaque as the most posterior of the left oviduct, but the albumen was not half deposited (Pl. 9b, fig. 4b); the more tenacious and denser portion, (*a*) which clings so closely to the yolk sac (*y*) when a young egg is broken open and the more external and nearly fluid portion drops away, was all that presented itself. Now under such circumstances, in order to allow the albumen to attain its destined bulk, the very elastic shell lining must stretch to a great extent; moreover the former probably solidifies as rapidly as it infiltrates, inasmuch as upon opening these eggs nothing but a thin, hardly consistent, jelly-like albumen pressed its smooth surface against the closely embracing shell membrane.

From the foregoing facts, it is evident that the concentric layers of albumen are not deposited by direct apposition of the glandular wall of the oviduct upon the yolk sac; so that, whatever turns the egg may make in its passage along the channel of the latter, this glairy envelope is not impressed with such a spiral arrangement of its strata as constantly obtains in that of Birds; consequently there are no chalazæ. Again: we may justly infer from this structure that there is no spiral motion of the egg, in its descent from the inlet to the outlet of its conduit, otherwise a simple inversion of the egg would not injure its contents, as experience has shown to be the case when inadvertently a Turtle was opened whilst laying upon its back, and the eggs were taken out in this abnormal position;[1] whereas in the albumen of Birds the chalazæ are formed early, and serve as axles, upon which the yolk sac swings and keeps its embryonic side uppermost, whilst the more exterior albumen revolves about it. Except to mention that the whole albumen is deposited before the calcareous deposition commences, we will defer any general remarks in reference to the shell until we come to describe its microscopic structure.

What we have just shown in regard to the albumen, the shell lining, and the shell deposit, leads very naturally to the question, What is the essential difference, between the mode of formation and the structure of these concentric layers, which renders them so distinct from each other, and how can they all be the product of one and the same portion of the same organ? The only reply we can make to the latter part of this question is, that it is just as possible for one organ, more or less complicated, to perform diverse functions, as that so simple a structure as an egg can produce, within itself, the multitude of functions which constitute the organic whole of an independent animal; but how this is done still remains among the mysteries inaccessible to our investigations. As regards the first part of the question, we will endeavor to answer it so far as our observations may guide us. We have already proved, by direct ocular demonstration, that the greater part, and, we would suggest, perhaps the whole, of the albumen is at times, if not always, deposited by infiltration through the already partially formed and synchronically developing shell-lining membrane. Now, notwithstanding this substance enters the confines of the lining membrane in a fluid state, yet it by no means continues in this condition, nor does it remain simply, as at the first glance it seems to be, a gelatinous, homogeneous bed, in which the yolk rests.

[1] On that account, Turtles ought always to be opened from above to examine the eggs.

The consistency of the fresh albumen of Turtles' eggs is much greater than in Birds; so much so that the shell and shell membrane may be stripped off, if removed before absorption is far advanced and the yolk and surrounding glairy envelope remain unchanged, and may even be taken up in the hand without sustaining any injury. It is also a very easy matter to strip off several layers, one after the other, even down to within one or two strata, or sometimes to the very last, which lies close to the yolk, without disturbing the latter in the least; in fact, these innermost layers of albumen seem to have considerably more consistency than those exterior to them.[1]

Upon making a transverse section of the thickness of the albumen, the edge of the cut presents the appearance of several concentric layers divided by dark lines; the distance of the latter from each other, and consequently the thickness of the former, varying according to the region of the mass to which they belong. If in a round egg, (Pl. 9b, fig. 6,) the strata (*a*) are equal throughout; but in an oval one (Pl. 9b, fig. 3) they are thickest near the ends of the egg, (*a*,) and gradually thin toward the shorter axis, (*c*,) at which point they attain to the minimum of thickness. Their number seems to vary according to the species; for instance, in Chrysemys picta there are six or seven, in Cinosternum pennsylvanicum about ten, and in Platypeltis ferox ten, etc. Further research is needed to ascertain how constant these numbers are in different species. Each stratum is composed of a clear, glairy albumen, in which minute, highly refracting, granular bodies of a more or less oval shape are densely packed and arranged in lines (Pl. 9b, fig, 3a, 6a); and these lines, as they are successively nearer and nearer the borders of the layers, approach each other, so that finally contact ensues between them; and hence their combination produces the dark zones. It is at these dark zones that the layers of albumen separate when peeled off. Where the strata grow thin, in oval eggs, the lines of granular bodies are closer together, (Pl. 9b, fig. 3a, 6a,) throughout the thickness of the layer, than elsewhere. It is further remarkable, that in oval eggs the albumen may be pulled off in layers transverse to the long diameter more readily than otherwise. Perhaps this is owing to the uniformity of its density in that direction, whereas it constantly changes toward the projecting ends of the egg.

When the albumen begins to be absorbed into the yolk sac, these strata are

[1] The above statements may be most fully sustained by opening the eggs of Chelydra serpentina, Ozotheca odorata, Cinosternum pensylvanicum, Nanemys guttata, Chrysemys picta, Glyptemys insculpta, and Cistudo virginea. We have not examined so closely our Western and Southern species in this respect, nor have we made any experiments respecting the temperature at which the albumen of Turtles coagulates; but would take this opportunity to refer to the interesting paper of Messrs. Valenciennes and Fremy upon the physical and chemical properties of the Turtle's egg. Comptes-Rendus, 1854, vol. 38.

resorbed at the upper side of the egg, not from within outwards, but, on the contrary, the most exterior ones first, and successively those more interior; each one, the moment it is perforated, by the loss of its substance at the point of resorption, shrinks away centrifugally, thus allowing the vitellus to rise gradually, till it finally touches the shell. In this condition, the strata appear as if cut across obliquely.

But let us return, and look a little more closely at the structure of this portion of the egg. Upon peeling off three or four strata, and viewing them perpendicularly to their surface, we instantly see that the dark lines mentioned above are the profiles of so many layers of oval granular bodies, and, more remarkable still, that the longer axis of all the oval bodies in one layer trend in the same direction (Pl. 9b, fig. 6b, *a*); whilst the longer axis of those in the next exterior or interior layer, although running parallel to each other, yet have a different direction from the last, running either at right angles, (fig. 6b, *b*,) or at thirty degrees, or with more or less divergence, from them (fig. 6b, *c*). This peculiarity holds good throughout the whole mass of the albumen; but it is not limited to this part of the egg. Before going further, we would point out the slightly nodular character of some of the oval granular bodies, which appear as if they were composed of two or three smaller ones. These bodies are very minute, comparatively, in some species, as in Glyptemys insculpta, but yet exhibit in their linear arrangement the same relation to each other in the different layers, as obtains in other species where they are much larger.

Those layers of the shell membrane which lie innermost and in contact with the albumen, hardly have a tenacity superior to the inner strata of the latter. This will not seem surprising when the structure of the two is compared, for then we find that they are scarcely to be distinguished from each other. The only difference noticeable is, that the granular bodies of the shell membrane are more elongated, and that each granule seems to be composed of a greater number of smaller granules than obtains in those of the albumen (Pl. 9b, fig. 6c). As in the latter, so also in the shell membrane, the granules of the different layers run in diverse directions, but parallel in the same layer. The distance of these layers from each other is almost nothing, just as is the case among the closest layers of the albumen; but, as there, an excessively hyaline granular film of albuminous matter fills up the interspaces.

Proceeding a little further outward, the oval granules of each layer approximate each other, and lie in contact, end to end, thus forming beaded fibres (Pl. 9b, fig. 6d); those in one horizon crossing those of another at various angles, as heretofore. Interspersed among them are minuter particles of various sizes and excessive faintness, imbedded in the albuminous film, and evidently arranged in lines, thus giving the field of view a striated appearance. As seen with a magnifying power of five hundred diameters, it is impracticable to represent these minute striæ with the pencil, except as the faintest lines possible. It will be noticed that the granules of the nodular fibres are not so large as those of the more interior layers; but this diminution is not constant, as will soon be seen.

In some species the different layers are very distinct from each other, (Pl. 9b, fig. 6e,) and keep their components so closely within themselves, that the passage from the one to the other seems almost an interval. This is particularly noticeable in Platypeltis ferox. Again, in others the irregularities of each layer fit into those of its neighbor; so that it is with difficulty that the respective boundaries of one or the other layer can be recognized.

As we advance outwardly, we do not find that the fibrous arrangement becomes regularly more and more apparent; but, on the contrary, here and there may be seen a layer, or rather two or three successive layers, composed of separate granular bodies, oftentimes much broader and coarser than the delicate fibres (Pl. 9b, fig. 6f, *b*) of the strata which lie on both sides of them, and still displaying their tendency to trend in particular directions (Pl. 9b, fig. 6f, *a*) in their respective layers. It is a very easy matter to peel off these coatings one from the other, and view them separately; yet, where three or four are superposed, there may be sufficient light transmitted to study them as they are naturally related. However, with these breaks in the continuity there occurs a pretty regular obliteration of the nodular appearance of the fibres, their components becoming gradually more and more intimately united to each other, as they are situated successively nearer and nearer to the outer surface of the shell membrane, till finally each fibre has become uniform and apparently structureless throughout its length. The outermost of these layers, next to the hard calcareous deposit, are composed of the smoothest and most uniform fibres, (Pl. 9a, fig. 45, and Pl. 9b, fig. 6g,) resembling at times excessively elongated tabular crystals. Before the shell is deposited, these layers may be recognized by the peculiarly brilliant nacreous appearance which strikes the eye. In Glyptemys insculpta, where this has been noticed most frequently, the component fibres are of excessive tenuity and compactness among each other, the latter feature tending, no doubt, to heighten the polished aspect of the surface of the layer.

The edge of a section made through the whole thickness of the shell membrane (Pl. 9a, fig. 43, *c*, *d*) appears more or less rough and dotted at intervals, where the ends of the fibres have been cut across at various obliquities; but between these the length of the threads may be recognized, and the layers distinguished, with more or less certainty, according to the species.

A few words are necessary in regard to the nature and origin of the granular bodies, which, in the shell-membrane, become the components of the fibres. Each granule has the appearance of being composed of three or four superposed concentric coatings, reminding one of the structure of starch granules. Now, what these apparent layers are has not been ascertained; but it does not seem possible that they should be the result of refraction, for that, as far as we know, would not produce more than one dark band, or a central dark spot, whilst here we perceive at least two bands within the outline and a central cloudiness, so that we feel justified in saying that in all probability they are concentric concretions. But this needs further investigation.

The thickness of the shell membrane varies greatly: in some species it attains to a very great crassitude; while in others it amounts to hardly one third the extent of the first. Thus, in Thalassochelys Caouana (Pl. 7, fig. 30) it is more than one half thicker than in Chelydra serpentina, (Pl. 7, fig. 24–26; Pl. 9a, fig. 43, *c*, *d*,) but with a quite thin and friable shell; whilst in Gypochelys Temminckii (Pl. 7, fig. 27) the shell membrane equals that of T. Caouana, but the shell is as thick as that of C. serpentina, and rather more dense than the latter, the calcareous nodules being more closely packed together.

Chelydra serpentina (Pl. 7, fig. 24–26) has the next thickest membrane, (Pl. 9a, fig. 43, *c*, *d*,) being almost two thirds as thick as in Thalassochelys, and a shell (*a*) equal to that of Gypochelys. Emys Meleagris (Pl. 7a, fig. 26, and 27) and Xerobates carolinus (Pl. 7, fig. 28, and 29) have a membrane of about the same thickness with C. serpentina; but the shell of E. Meleagris equals that of C. serpentina, while that of Xerobates is more than one half thicker than in these two species, and far more dense and brittle.

Glyptemys insculpta (Pl. 7a, fig. 15–17) and Ptychemys concinna (Pl. 7a, fig. 20–23) also have shell membranes as thick as the last; but the shell of Ptychemys is two thirds as thick as in Chelydra. Graptemys geographica, (Pl. 7a, fig. 28–30,) Nanemys guttata, (Pl. 7a, fig. 7–10,) and Cistudo virginea, (Pl. 7, fig. 10–14,) have shell membranes hardly as thick as in Chelydra, and the shell half that of the latter.

Cinosternum pennsylvanicum (Pl. 7, fig. 1–6) has a shell membrane two thirds as thick as in Chelydra; its shell, however, nearly equals, in this respect, that of Xerobates carolinus, but is more dense and brittle than the latter.

Chrysemys picta (Pl. 7a, fig. 1–3) has a shell membrane and a shell equal to one another, as regards thickness; and both together only equal the shell membrane of Chelydra. The shell membrane of the egg of Platypeltis ferox (Pl. 7, fig. 2) is about equal to that of Chrysemys; but its shell is much thicker, about one sixth thicker than that of Chelydra.

The shell membrane of our Ozotheca odorata (Pl. 7, fig. 7–9) is much the thinnest of all known to us, being about one half as thick as that of its congener Cinosternum; and yet its shell is slightly thicker than that of Chelydra.

The annexed table will give a graphic view of the relative thickness of the shell and shell membrane of the different genera of Turtles. The line which runs between the columns, marked "shell" and "shell membrane," indicates the junction of the two. The length of the straight lines on the left shows the thickness of the shell membrane magnified to five hundred times its diameter; and the straight lines on the right, the thickness of shell under the same amplification.

GENERA AND SPECIES.	SHELL MEMBRANE.	SHELL.	SHELL STRUCTURE.
Chelonioidæ.			
Thalassochelys Caouana			Nodular, nodules very friable.
Trionychidæ.			
Platypeltis ferox			Continuous surface.
Chelydroidæ.			
Gypochelys Temminckii			Nodular surface, nodules hard and brittle.
Chelydra serpentina			
Cinosternoidæ.			
Ozotheca odorata			Continuous surface.
Cinosternum pennsylvanicum			
Emydoidæ.			
Graptemys geographica			Nodular surface, nodules hard and brittle.
Ptychemys concinna			
Chrysemys picta			
Nanemys guttata			
Glyptemys insculpta		?[1]	
Emys Meleagris			Nodular, but smooth and hard.
Cistudo virginea			Nodular surface, nodules hard and brittle.
Testudinina.			
Xerobates carolinus			Continuous surface.

The Shell. As we have already indicated the thickness of the egg shell, when speaking of that of the shell membrane, we will at once pass on to describe the mode of development and the structure of this, the most superficial of the different layers surrounding the egg.

By dissolving the carbonate of lime of the shell with nitric acid,[2] the basis of

[1] The eggs had not yet matured their shell.

[2] Nitric acid decomposes the carbonate of lime very rapidly till it becomes saturated, and, upon evaporation, deposits groups of crystals, (Pl. 18, fig. 11,) which exhibit the characteristic, long, tabular, rhombohedral forms of nitrate of lime (fig. 11a, 11b, *a*, *b*).

this solid deposit is found to be composed of a fibrous substance similar to, and no doubt identical with, that of the shell membrane, but of a much more tender and less dense consistency, (Pl. 9a, fig. 43c,) varying according to the species to which the egg belongs. Thus, in Chelydra serpentina it equals about one third the thickness of each shelly nodule (fig. 43, *a*) of which it formed the basis; in Platypeltis ferox it bears about the same proportion; but in Cinosternum pennsylvanicum it dwindles down to almost one sixth that of its shell, and is much more tender and transparent than in the two above-mentioned species, indicating that there is far less organic substance for the calcareous deposit in this Turtle than in the others.

In these three species, radiating lines spread out, from the centre of the base of the nodule (fig. 43c, *b*) toward the surface *a*, just as in the calcareous state (fig. 43, *a*, *b*); no doubt impressed upon it by the columnar arrangement of the crystals of carbonate of lime, which trend in this same direction, as will be seen presently. In those shells where the structure is evidently nodular, as in Chelydra, (Pl. 9a, fig. 42, 43, *a*,) the basis, deprived of its lime, still simulates its former shape, (43c,) although, as we have said, on a reduced scale; but where the surface of the shell is smooth and uniform, as in Cinosternum and Platypeltis, its basis, when treated as above, is continuous all over the egg as a wavy stratum, each wave corresponding to a group of crystals of carbonate of lime.

On examining an egg of Chelydra in which the shell is still soft and but very little lime has been deposited, we find that the surface of the shell membrane is striated by lines running parallel to the axis of the oviduct, and that these lines are composed of rows of nodules, (Pl. 9a, fig. 44,) which, upon closer inspection, are found to present the characteristic forms in which the crystals of carbonate of lime group themselves (fig. 44a). Every little nodule, viewed from the outside, appears striated concentrically and radiatingly, each ring between two successive concentric striæ representing a stratum of crystals, the sides of which are indicated by the radiating lines. The centres of crystallization vary in their distances from each other: in some instances they are very close together, so that the increasing nodules soon press against their neighbors, forming a straight line of contact; in other cases, where they are further apart, they retain their globular form much longer. Those which are formed early seem to be flattened against each other more than those formed later, which fill up the spaces between the original series. The earliest indications of these nodules are little, clear, homogeneous, globular masses, scattered here and there, which, as they increase in size, begin to show faint, radiating, and concentric striæ. These striæ soon develop themselves strongly, so as to be seen without difficulty, as in the nodules which we have described as arranged in lines. In fully perfected nodules this striation is quite strong and sharp, (Pl. 9a, fig. 43a,) when seen from the same point of view; and in this case the outline of each nodule is serrated irregularly by the projecting ends of the crystals.

When a section is made through the thickness of a nodule, its centre, at the base, (Pl. 9a, fig. 43, *b*,) is seen to be the point from which all the radiating lines proceed to the surface, and the concentric lines, in the view from above, (fig. 43a,) both at this age and also in the young nodules, (Pl. 9a, fig. 44a,) appear arched, showing that the lime crystals are arranged as if around a sphere, the centre of which coincides with the starting point (Pl. 9a, fig. 43, *b*) of the radiating lines, and that these radiating lines (fig. 43, *a*, *b*, 43b) are the long sides of the prismatic calcareous crystals.

It will readily be seen, here, how air and moisture may gain access to the interior of the egg, when we consider that the nodules (Pl. 9a, fig. 42, 43, *a*, *a*[1]) are not soldered to each other laterally. In the case of hard, brittle, and smooth shells, however, such as those of Xerobates, Platypeltis, Cinosternum, and Ozotheca, (in which the groups of crystals become interlocked with each other by the dovetailing of their ends at the basal and younger portions of the nodules, and the later developed and more exterior parts of these nodules so confuse the terminations of their adjoining crystals as to disguise their line of junction, and thus form a continuous stratum from one of the nodules to the other, like a universal bridge over the whole egg,) open spaces must be left in the lime deposit, in order that this may obtain, and we actually find it to be the case. In some species these spaces are quite numerous, as in Ozotheca (Pl. 9a, fig. 46); but in others they are more rare, for instance, in Platypeltis and Xerobates.

From the remarks annexed to the table which we have given, (p. 508,) it will be seen, that, within each family of Turtles, the peculiarities of the egg shell are the same throughout. Thus, in the Chelonioidæ it is nodular, and each nodule widely separate from its neighbors, and very ragged and friable; in Trionychidæ it has a continuous smooth surface bounding a uniform, dense, brittle stratum, which equals about one third the thickness of the nodules beneath; in Chelydroidæ it is nodular, (Pl. 9a, fig. 42, 43, 43a,) and each nodule is smooth, hard, and brittle, and separable from its neighbor, although at the time of their formation they may sometimes be in contact with each other; in Cinosternoidæ its continuous surface is wavy or pitted, terminating a uniform stratum, just like that of Trionychidæ, excepting that here it is about twice as thick, and fully two thirds the depth of the nodular part beneath; in Emydoidæ it is nodular, the nodules being similar in structure to those of the Chelydroidæ, but more closely united to each other, especially in Emys Meleagris, (which by the way belongs to a distinct sub-family of Emydoidæ,) where they are very closely set together, so that the shell is quite smooth and hard; and, finally, in Testudinina it has a continuous, smooth, wavy surface, underlaid by a uniform stratum, as in Trionychidæ and Cinosternoidæ, and similar in structure and hardness with these, but much less in thickness, and only equalling one fifth the thickness of the nodules below.

SECTION III.

THE ABSORPTION OF ALBUMEN INTO THE YOLK SAC.

In the last section, we have described the mode of origin and deposition, and the structure of the albumen of the Turtle's egg. In this section, we propose to show what becomes of that albumen, and what connection it has with the yolk mass, around which it is originally deposited.[1]

The youngest and least advanced egg which we have observed, after the last fecundation, was one of Glyptemys insculpta, with an oval shell and a full complement of albumen, in which segmentation had just begun (Pl. 10, fig, 1, 1a). In this instance the yolk mass had already lost the globular form which it possessed in the ovary, and assumed an oval shape. This oval figure would not, at the first glance, intimate that there was any connection between the yolk and the albumen which surrounds it; when, however, we observe besides, that not only the shape of the yolk mass is changed, but its size also is increased, we very naturally infer that this augmentation in bulk is due to the introduction of some substance from without mixing with the yolk, and, as the albumen includes the yolk, that this is the substance in question. Whether the albumen, in this case, was absorbed as soon as it began to be deposited around the yolk, or not till its deposition had gone on for some time or had even been completed, it is not possible to say definitely; but inasmuch as in the case of a much older egg, (Pl. 9b, fig. 4b,) in which segmentation in the region of the embryonic area was already completed and the embryonic disc well defined, (*c*,) the yolk sac was plainly oval, (*y*,) and larger than when it left the ovary, whilst the albumen was as yet only partially deposited in a thin layer, (*a*) and no shell was present,[2]

[1] Before proceeding to the consideration of this subject, the reader may with advantage take a retrospective glance at the earlier stages of growth of the ovarian egg, and to that effect compare the diagram of the egg represented Pl. 9c, fig. 1 with that of fig. 2 upon the same plate, and also that of Pl. 9d, fig. 3.

[2] This instance shows that the oval shape of the yolk mass is not derived from the impression of the shell acting as a mould upon its contents, since no shell was as yet present; but arises no doubt from the tendencies inherent in the life of the egg and its development.

we infer that the earliest layers of albumen were at once liquefied and drawn within the yolk sac. This view of the case seems to be warranted by the fact, that the layers of albumen still outside of the yolk sac, are, to all appearances, undisturbed and perfectly symmetrical all around the egg, even after the yolk sac has assumed an oval form. No further alteration of the yolk mass connected with the absorption of albumen was noticed in much older eggs of this species, (Pl. 10, fig. 11a, 11b,) up to the time when the embryonic area became a distinct disc (fig. 15a).

The mode of absorption of the albumen mentioned above, and the consequent change in the shape of the yolk sac, have been observed in the oval eggs of several other genera of the family of Emydoidæ, namely, in Nanemys guttata, (Pl. 9b, fig. 1a,) Chrysemys picta, and Cistudo virginea (which had the same aspect as Pl. 10, fig. 15a). In these the embryonic area was already a distinct disc, (Pl. 10, fig. 12, 13, 14,) and the albumen and shell were complete.

The yolk of the oval eggs of at least two other genera (Ozotheca and Cinosternum) belonging to another family, the Cinosternoidæ, does not assume an oval form so early as in the Emydoidæ. It does not appear even that the albumen mixes at all with the yolk in the beginning, as is the case in the eggs of Emydoidæ. At least, in all the younger eggs of the family of Cinosternoidæ which had already a shell, the albumen was arranged in perfect symmetry around the yolk mass; and the latter was perfectly globular, and to all appearances not larger than when it left the ovary (Pl. 9d, fig. 4). In the eggs of the Testudinina, Trionychidæ, Chelydroidæ, and Chelonioidæ, which have a globular shell and a globular albuminous deposit, neither an oval form nor an increase in the size of the yolk mass has been observed as long as the yolk remained homogeneous. In fact, the earliest period at which we have known the albumen to enter the yolk sac of the eggs of the families just mentioned was when the cephalic hood had already began to form (Pl. 11, fig. 1, 1a; Pl. 9b, fig. 5, 7, 7a); and then the albumen bore a very different relation to the yolk mass from that in the cases pointed out before, as will presently be shown.

Notwithstanding the infiltration of a small portion of albumen in some of them, the eggs of all Testudinata, whether their shell be oval or round, retain a homogeneous aspect till the embryonic disc has assumed a sharply defined outline (Pl. 9b, fig. 1a, *e*, 4b, *c*; Pl. 10, fig. 12, 13, 14, 15, 15a). But it is a significant fact, that, at this period, the oval egg shell of the family of Emydoidæ should contain an enlarged oval yolk mass, whilst the oval egg shell of the family of Cinosternoidæ contains a yolk mass which is perfectly globular, and not larger than when in the ovary.

We have already mentioned, that all eggs with globular shells retain, until the embryonic disc is sharply defined, not only the same homogeneity, but also the same size, that obtained when they were in the ovary. We would recall this fact again, in order to allude more directly to the similarity in the conduct of the yolk mass in the oval eggs of Cinosternoidæ with that of the families which have globular eggs.

Immediately after the embryonic disc has become sharply defined, we perceive a remarkable change in that portion of the yolk mass which lies just below the embryonic area (Pl. 9b, fig. 1, a^1, 4, a^1, 4a, a^1, 5, a^1; Pl. 11, fig. 1a). At this spot, a small quantity of clear fluid makes its appearance. Below, it rests on the great mass of yolk, (*y*,) and above, presses against the under-side of the embryonic disc (*c*) and its continuation, the germinal layer. Seen from above, the space which this fluid occupies appears dark, unless light is admitted through the side of the egg; but in profile it is as clear as glass. This, however, is not seen very readily, unless the slightly opaque germinal layer that surrounds the whole egg is broken through. The embryonic disc is also rendered more distinct and conspicuous by the presence of this dark background. At the same time, a slight enlargement of the yolk sac is noticeable. From these facts, we at once infer that the clear fluid under the embryonic disc does not arise from a liquefaction of a portion of the yolk mass, but that it is introduced from without, and is the cause of the increase in the size of the yolk sac. We are confirmed in this belief when we look at that portion of the albumen which overlies the embryonic area,[1] and there find that a more or less circular portion

[1] The manner in which the albumen is absorbed into the yolk sac in the eggs of Birds seems not to have been observed with sufficient care. This process is very peculiar, and stands in direct relation to the embryonic area, and to the increase of the yolk sac. Nothing is easier than to ascertain the precise amount of albumen that is absorbed into the yolk at successive periods of incubation, and the changes of form which the yolk sac undergoes in consequence of this absorption. It is only necessary to boil the eggs slowly, when the albumen discloses at once the changes it has undergone. Its absorption is at first distinctly circumscribed to the area above the embryonic disc; and the limits within which it takes place are so sharply defined, that, when the albumen is hardened by heat, there may be seen, above the growing germ, a hollow, truncated cone, (Pl. 9d, fig. 5,) the broad base of which is turned towards the shell, while its truncated apex, turned towards the yolk, corresponds in width to the diameter of the embryonic disc. As the embryo increases, the cone appears gradually flatter and flatter and more truncated, until the broad embryonic disc occupies the whole space in the upper part of the egg immediately below the shell membrane. The changes which the form of the yolk sac successively undergoes are not less characteristic: at first spherical, it is gradually more and more flattened within the limits of the embryonic area, until, by the time the area equals the diameter of the yolk sac, it is very nearly hemispherical, the flattened side being only slightly raised in the centre. I intend to publish, on another occasion, a series of drawings representing these interesting changes, as observed in hens' eggs; meanwhile I would seriously call attention to these facts, as they show clearly that the changes which the albu-

in the outermost layers of this glairy substance has disappeared, and that the layers thus affected have shrunk toward the opposite side of the egg (Pl. 9b, fig. 3, *a*, 4, *a*, 5, *a*, 7, *a*). In this way the more interior layers of albumen become pressed against the shell, and the enlarging yolk sac on that side follows in their wake. In oval eggs, this absorption usually takes place at the side, midway between the two ends. Sometimes, however, when the egg is laid so as to rest in the nest with one end uppermost, the yolk mass shifts also, and the more buoyant portion, where the embryonic disc originates, faces toward the higher end of the shell; and here, too, the absorption of albumen first finishes: always above the embryonic disc, wherever it may be. In consequence of these changes, the centre of the yolk mass has not remained concentric to the outline of the shell, whether it be oval or spherical, and the layers of albumen appear proportionably much thicker on the under-side of the egg. It is very important to know that the absorption of albumen, and its infiltration into the region below the embryonic disc, commence in the oviduct, and not after the egg is laid; as we are thus enabled to determine at what part of an oval egg the albumen normally first enters the yolk sac.

Upon carefully opening a Turtle from above without disturbing the oviduct, it is possible to ascertain the exact position of every egg within the animal, and its relation to a horizontal plane. The embryonic disc, (that part of the egg which corresponds to the region of the cerebro-spinal axis,) is always next to the back of the animal. It is not, however, at all times situated at the highest point of the egg, nor as near as possible to the back of the Turtle, but may be found now and then down toward the side of the egg (Pl. 11, fig. 4a). The longer axis of oval eggs is usually horizontal, and the shorter axis perpendicular; so that, consequently, the longer curve of the shell is horizontal also, within the animal, excepting, perhaps, occasionally a slight elevation at one end, when the egg happens to be in a part of the oviduct which bends rather suddenly upon itself. Now if, within the oviduct, the embryonic area is always situated next to the back of the animal, it rests, of course, midway between the two ends of the oval egg, next to its longer curve, at what would naturally be called its side (Pl. 9b, fig. 1, 2, 2a, 3, 4, 4a). This, doubtless, is its normal position. The absorption of albumen normally commences above this point, as may readily be seen by opening Turtles just before the laying season. Therefore it is abnor-

men undergoes are intimately associated with corresponding changes in the embryonic disc and in the yolk sac, and do not take place in a manner to favor the idea that the albumen is merely a mass of nutritive substance accumulated around the yolk. On the contrary, these changes prove that the albumen is organically connected with the yolk, and performs a regular function in the growth of the embryo.

mal, that the absorption of albumen should change from the place where it began and go on afterwards near the end of the shell, as is the case when the eggs were laid obliquely in the nest, as we have mentioned above. However, in this latter instance, the development of the embryo does not appear to be hindered. From these facts, we can very readily see that the longer curve of the oval egg corresponds, in a general way, to the sides of the globular egg, which run parallel with the longer axis of the animal.

The absorption goes on encroaching successively upon the more inner layers of albumen, till all have been pierced in the part which lies above the embryonic disc, and the much enlarged yolk sac touches the shell. There is a considerable degree of regularity in regard to the rapidity with which the albumen is resorbed. At the time it begins to infiltrate into the yolk sac and to occupy a space below the embryonic disc, the cephalic hood has just begun to form (Pl. 11, fig. 1, 1a; Pl. 9b, fig. 1, 4, 4a, 5, 7, 7a). Sometimes, however, the cephalic hood does not appear till the yolk sac is almost one third filled with albumen (Pl. 9b, fig. 2, 2a). In the oval eggs of Cinosternoidæ, so far as we have observed, the yolk sac becomes half full of albumen before the sac itself loses its globular shape, or the cephalic hood begins to form, or any change comes over the embryonic disc (Pl. 9a, fig. 41, 41a). Soon after this, however, the yolk sac (Pl. 9b, fig. 3, *y*) elongates slightly towards the ends of the egg, and becomes broadly oval as the albumen (a^1) continues to be absorbed. When the yolk sac is one third filled, (Pl. 11, fig. 3a,) the cephalic and caudal hoods are quite deep, and the primitive furrow has just appeared (Pl. 11, fig. 3, *b*) at the cephalic end of the embryo. Sometimes the primitive furrow has not appeared, (Pl. 11, fig. 4,) even when the yolk sac is nearly half full of albumen (Pl. 11, fig. 4a). By the time all the layers of albumen have been pierced (Pl. 9c, fig. 2) by the absorption of their substance, and the yolk sac has become more than half filled with albuminous fluid, and its upper side touches the shell, (Pl. 11, fig. 5b, 5c,) the head of the embryo is much bent upon itself, (Pl. 9e, fig. 4,) and the primitive furrow (Pl. 11, fig. 5, *b*, 5a, *b*) extends along more than one half the length of the cerebro-spinal axis. Judging from the large amount of clear fluid already within the yolk sac, a portion of the yolk must have become liquefied, since the infiltrated albumen alone could not take up so much room.

There remains considerable albumen to be resorbed after this period. After rising so high as to touch the shell, the yolk sac has nothing further to absorb directly from above, and therefore the remainder of the albumen must enter at the side and below. This goes on till, by the time the process is finished, the shell is filled by the distended yolk sac. At what time all the albumen becomes infiltrated into the yolk sac we cannot say definitely, since we have not traced the progress of this process to its completion. The egg of Chelydra serpentina is that in which we have followed most carefully the successive steps of the absorption of albumen, up to the period when the yolk sac is more than half full of clear fluid. At this last-mentioned stage of the resorption of albumen, the egg had been laid about three days and six hours. In an egg of Ozotheca odorata a week old, the albumen was all within the yolk sac. This also obtained in eggs of Thalassochelys Caouana of the same age (Pl. 9b, fig. 8).

In both these cases, however, the embryo was not so far advanced in development as at the last stage to which we have traced this process in the egg of Chelydra serpentina. After the yolk sac is filled, the yellow part of the yolk mass continues to lessen in size, and the space above it, containing the clear fluid and the cerebro-spinal part of the embryo, to increase in magnitude, until the period when the Turtle leaves the shell. The older the egg, the more distended does the shell appear, so that, when a mere pinhole is opened in it, a portion of the contents protrude through the aperture. This becomes very troublesome when investigating those eggs which have a flexible and elastic shell, like that of Chelydra; for, in such cases, the moment an opening is made, the confined fluid tears open the embryonic envelopes[1] and rushes out in a forcible jet, causing the embryo to assume an unnatural position.

SECTION IV.

THE TRANSFORMATIONS OF THE YOLK IN THE FECUNDATED EGG.

In the preceding chapter[2] we have described the mode of formation of the yolk, and its successive changes prior to the last copulation. We have now to consider the changes which it undergoes after this period.

The yolk cells continue to grow, in certain respects, after the egg has entered the oviduct. There is, at this stage, something unprecedented in the unceasing enlargement of the mesoblast, until it finally so fills the ectoblast that the wall (Pl. 9a, fig. 33b) of the latter is hardly to be distinguished from the encroaching surface of the former. To an unprepared eye, especially if one had not seen the intermediate steps, (Pl. 9, fig. 11f, 11g; Pl. 9a, fig. 2d, 33a, 33b,) the mesoblast would appear destitute of any wall beyond its own (fig. 39a–39e); but

[1] This tearing of the egg membranes may be prevented by making a hole in the lower side of the egg and letting out a portion of the yolk, especially in instances when it is not desirable to keep the latter intact for further investigation.

[2] See p. 458–475.

there cannot be the least doubt that the faint, thin line (Pl. 9a, fig. 33b) which presses closely upon the dark contour of the mesoblast is the wall of the ectoblast; for, even were it not possible to follow with the greatest ease the gradual diminution of distance between the two approaching surfaces until contact ensues, the action of water, which bursts and peels off the outer membrane, would alone serve to prove its existence.

This filling of the ectoblast by the mesoblast is not a feature peculiar to fecundated eggs found in the oviduct, although it belongs in a great measure to that condition of the ovum; for its beginning has been noticed (Pl. 9a, fig. 33a, 33b) in one egg, taken from the oviduct of a female known to have been kept from the male during a whole year. But, just as segmentation of the yolk proceeds to a certain extent in the unfecundated eggs of some animals, so here the filling of the ectoblastic cell may occur as a phase continued up to a limited amount of the yolk; beyond which, however, the stimulus of fecundation is necessary, in order that the process may go on throughout the whole vitelline mass.

But there is a further change, in the nature of the yolk cells, which belongs exclusively to the eggs found in the oviduct; and that is the sudden multiplication of the number of the entoblasts, (Pl. 9a, fig. 1, 2a, *a*, *b*, *c*, 39d, 39e,) amounting, in some cases, to hundreds in each mesoblast, and, in most instances, still preserving their rounded form. From what we have sometimes seen in fecundated eggs where more than half the yolk cells were totally destitute of entoblasts and the remainder for the most part faintly entoblasted, as if these waxy masses were deliquescing, we have good reason to believe that this last feature in the life of the entoblast is brought about by a total renascence of entoblasts, after the plan of their first appearance in young ovarian eggs, and not by any subdivision of each crystalloid body into several smaller ones. That this novel conduct of these bodies is intimately connected with the genesis of the embryo there is abundant proof in the fact of its simultaneousness with another still more remarkable and most important phenomenon, hitherto unsuspected as playing a part in the life of the yolk cell of any animal, namely, a self-division of the mesoblast.

How long before the segmentation of the yolk this process commences has not been established; but certainly it may take place without the last fecundation, since it was observed in eggs that had not been permeated by this quickening influence within a year (Pl. 9a, fig. 33). This may readily be proved by confining the females apart from the males during the breeding season, and opening the eggs just as they enter the oviduct, when it may be seen that subdivision of the mesoblast has proceeded to a certain extent without the help of any recent stimulus. In such eggs, this self-division of the mesoblast was noticed and recorded as the earliest observed occurrence of this peculiar phenomenon. This is enough to establish its independence of fecundation within a year. But, since the self-division of the mesoblast was not remarked as occurring in eggs just about to drop from the ovary into the pavilion of the oviduct, it must be considered, without doubt, as an intra-uterine phase, commencing before the completion or even before the first appearance of the shell, since the latter was still quite soft and thin in a fecundated egg in which the segmentation of the yolk had but just separated a small area of the surface of the yolk into eight portions, and since it was altogether absent in several eggs whose embryonic disc was well marked.

Moreover, from what we have seen in the yolk of the thin shelled egg just mentioned, and considering also that the segmentation of the yolk was not far advanced, it may be safely inferred that the self-division of the mesoblast begins before the other process. Judging from the heaps of already minute and numerous mesoblasts (Pl. 9a, fig. 35) in the segmenting mass, at the period when segmentation begins, (while but a single mesoblast existed before in each ectoblast,) and also from their presence all over the superficies (fig. 35a) of the egg, (their parent envelope, the ectoblast, having disappeared in both cases,) we may further say, that the self-division of the mesoblast is in fact a forerunner of the segmentation of the yolk, wherever this occurs, whether it be at the blastoderm, or over the whole surface of the yolk mass, as we shall presently attempt to show.

As we have already mentioned, the earliest period, at which self-division of the mesoblast has been observed in an egg fully fecundated, belongs to that age when the embryonic area is divided into but eight parts, (Pl. 10, fig. 1, 2, 3,) and heaps of numerous mesoblasts exist, (Pl. 9a, fig. 35a,) which, we can safely affirm,—although we ascertained that in this instance they had lost their parent cell, while its presence (fig. 34, *b*) around those belonging to a little older embryonic disc (Pl. 11, fig. 3) and to that portion of the germinal layer exterior to this was satisfactorily made out,—had evidently originated from a frequent repetition of that same process which at first, in the more internal portion of the yolk mass, simply doubled (Pl. 9a, fig. 33, 36–36c, 37–37d) the single mesoblastic bodies, as exhibited in the figures here referred to. In such instances, the wall of the ectoblast, which in the case of undivided mesoblasts is very obscure, (Pl. 9a, fig. 33a, 39a, 39b, 39d, 39e,) was rendered very conspicuous, as it bridged over the constricted portion; but again became more or less indistinct where the mesoblastic masses had multiplied considerably, as may readily be seen in eggs scarcely older than this (Pl. 9a, fig. 7, 9, *a*, 38, *a*, 38a, 38b, *a*, 38c). These last eggs presented abundant materials for the investigation of the self-division of the mesoblast, from its beginning, through all degrees of multiplication, until the mesoblasts have become very numerous. We will, however, refer at the same time to figures illustrating this subject in younger, and in some much older, stages of growth.

At first the mesoblast constricts gently, so as to leave a broad sinus between the separating portions, (Pl. 9a, fig. 37, 40,) then a little later its constriction becomes narrower as it grows deeper, (fig. 40a, 40b, 40c, 40d,) till finally it divides into two (Pl. 9a, fig. 36–36c, 37a–37d, 38, 40e, 40f, 40g); then each of these again doubles itself. Sometimes the one division begins before the other, so that there is a triple mesoblast (fig. 40h, 40i); or, in the case of the next phase, one of four doubles previous to the others, (fig. 38b, 40j,) thus producing a quintuple mesoblast; and so on, again and again, almost to infinity, we might say, when we consider the innumerable quantity of these bodies (Pl. 9a, fig. 9, *a*, *b*) in each ectoblast, at the time they have just entered the boundaries of the embryonic disc and become part and parcel of the embryo. In this connection we may express the opinion, that it is very probable that the entoblast also segments, since in some instances (Pl. 9a, fig. 40d, *c*) it is so large as to make it almost impossible that it should enter entire into either of the two portions of a duplicated mesoblast. In several other cases the entoblast has been observed in the same position (fig. 40, 40a, *c*, 40c, *c*) as in the former, directly in the line of the approaching constriction; but in these cells it might, considering its size, be forced into either segment by the narrowing strangulation.

We have good reason to believe, that the phenomenon of self-division of the mesoblast obtains throughout the period of incubation of the animal; at least, it was observed in an egg two months old, (Pl. 9a, fig. 40–40b,) which is half the time required to develop the Turtle; and, on the day the animal left the shell, the still pendent yolk sac contained cells of the largest size, having each but a single undivided mesoblast (Pl. 18, fig. 4a); so that, at best, it cannot be said that the self-division of the mesoblast had pervaded the whole yolk at the time of hatching. Again: *this process does not go on uniformly throughout the yolk at one time*, but has a centripetal aim, provision for the embryonic disc (Pl. 9a, fig. 7, 35) and the germinal layer (fig. 3, 35a) all round the yolk sphere, being first made, previous to segmentation; then the next more interior portions become the seat of action, and so on, deeper and deeper.[1]

By referring to cells (Pl. 9a, fig. 7, 7a, 9, *a*, *b*) taken from the embryonic disc and from the germinal layer (fig. 3) after segmentation, we may gain abundant evidence, that, even at this period, the self-division of the mesoblast has not finished its part. This may be confirmed by resorting to an embryonic disc a little older, where the cephalic hood is just about to be formed, the depression all

[1] Such cells were observed from the centre of the yolk mass, from the surface, and midway between these points, and found everywhere alike, but in greater proportion near the surface, where they seemed to be quite numerous; those divided into two being by far the most frequent. Both the mesoblast and entoblast, throughout the yolk mass, are very faintly yellow.

round the germ being already present as an indication of the incipient plication of the amniotic membrane; and here the greater part of the mesoblasts are still further and more minutely divided, (Pl. 9a, fig. 4, 5, 5a, 6, 8,) and reduced to that size (fig. 34, *a*) which they exhibit when the organs have begun to mark out their boundaries.

But, let us return and trace more critically the changes through which the yolk cells pass, in order to reach that condition in which they are found when they have become components of the nascent embryo. By the time that the segmentation of the yolk has commenced, not only the cells in the region of the embryonic area, but those all over the surface of the yolk close to the vitelline envelope, have multiplied their mesoblasts to an innumerable number. In this state, they may be recognized as a very light yellowish white layer, which — when the egg is rolled in various directions, the more interior yolk thus falling to what becomes, in succession, the lower side, and this layer is left more exposed — resembles a very fragile, sedimentary deposit against the yolk sac, falling away in flakes upon the least flexure or disturbance of its smooth, crust-like arch. Owing to the rapid formation of this layer, and the quickly succeeding ultimate changes in the cells, the latter seem to burst almost in an instant, and leave their mesoblasts arranged in heaps, (fig. 35a,) side by side, thus forming the brittle stratum above mentioned. The superficial ectoblastic cells of this layer discharge their mesoblasts so early before the self-division of the latter has been completed, that it is next to impossible to find among them ectoblasts still embracing their progeny; but this may be accomplished in regard to those more deeply seated, especially next to the inner surface of the stratum. We will first make a special mention of these latter, and then return to the former to trace their progress in completing the stage of their fissiparous multiplication, and the connection of the same with the building up of the embryo.

By cutting out an embryonic disc and laying it upon its back in a watch-glass containing albumen from the same egg, it is very easy to select whatever portions are needed from this body for this purpose; the substance hanging together so lightly that a few cells may be taken up on the point of a knife and laid upon a glass slide for examination, or, for those most superficial, the microscope may be brought to bear directly on them in situ. Of course, in the latter case, a strong, concentrated light from above is necessary, on account of the opacity of the embryonic disc, which precludes the possibility of using transmitted illumination. The innermost cells, the ectoblasts, of the germinal layer and of the embryonic disc,[1] are still

[1] If, however, there are those who still incline to believe that these cells are genuine segment balls, then they must, even upon this supposition alone, admit also, without reservation, that segmentation

found inclosing their mesoblasts (Pl. 9a, fig. 9, *a*, *b*) after segmentation has completed its purpose, and even at the time the cephalic hood has begun to form (fig. 34, *b*). Almost to the last moment before losing its identity as one of the many belonging to a particular heap, each mesoblast can be recognized and distinguished from the waxy bodies, the entoblasts, which it usually incloses in greater or less numbers, (Pl. 9a, fig. 9, *a'*,) by the peculiar mesh-like condensation of its viscid contents upon the inner surface of its wall (fig. 9, *a''*). This may be seen, even in those which rival in minuteness the cells of a much further advanced embryonic disc. (Compare fig. 9, *a'*, with fig. 8).

Not only the mesoblast, but the ectoblast also, gives the peculiar reaction formerly noted in regard to the cells of the interovarian egg, when water is applied; for, just as in these latter, the ectoblast swells up, and, finally bursting, after the transparent fluid contents in which the mesoblasts float have condensed into a swarm of minute oscillating particles allows them to escape, discharging at the same time its multitude of mesoblasts (Pl. 9a, fig. 7, 7a).

Going deeper into the substance, and more toward the back of the embryonic disc — or, more properly speaking now, the back of the embryo — and the outer surface of the germinal layer, the heaps of mesoblasts become less and less distinct, owing to the closer application of the wall of the ectoblast against the mulberry-like surface of the mesoblasts, (Pl. 9a, fig. 4,) so that the mesoblasts of adjacent heaps interlock with each other to the confusion of the outline of each mass. Finally, almost at the outer surface of the yolk, the ectoblasts have disappeared entirely, (Pl. 9a, fig. 5a,) though the mesoblasts still remain in heaps, with more irregular outlines than is usual. The disappearance of the ectoblasts is so gradual, so imperceptible, that we have good reason to believe that they are slowly disintegrated and liquefied, the result mixing with the surrounding fluid. The now free heaps of mesoblasts extend their boundaries in an irregular manner, inosculating with each other by the intermixing of their most superficial components (fig. 5, 6). Even here the mesoblasts retain their entoblasts, sometimes to the number of three or four in each, (fig. 5a,) and withal exhibit their vitelline character. The same may be

occurs not only on one side, but all over the surface, of the yolk, for the very reason that these identical "segment balls" are found upon the whole superficial extent of the egg, (Pl. 9a, fig. 4, and 34, *b*.) and, to a certain depth, inwardly. But we think this total segmentation may be proved upon totally different premises, so that what we have just said above may be left for the consideration of those who would hold both to the partial segmentation of the yolk and to the development of a wall around the segment masses, as is said to occur in Birds. By commencing our investigation of the subject with these "segment balls," and tracing their development in a retrograde series, beginning with Pl. 9a, fig. 9, and receding through fig. 7, 4, 34, *b*, 36–36e, 37–37d, 38–38e, 40–40l, we find that the first steps toward their formation are taken in the midst of the great yolk mass, the very spot from which segmentation is excluded by the advocates of partial and superficial segmentation in the classes of Birds and Reptiles.

said in regard to the superficial or outermost layer of mesoblasts, (fig. 8,) which have departed from their cumulated arrangement, and present a uniform stratum all over the surface of the embryonic disc and of the germinal layer.

Everywhere the mesoblasts are now spread uniformly, in unbroken continuity and in close contact, yet not pressing against each other so as to assume a polygonal form. Even at this late period, intimately identified as these bodies are with the embryo, their fissuration is in many instances not yet complete, (fig. 8,) judging from the inequality of their size, when compared with their uniformity in that respect at a later age (fig. 34, *a*). In fact it is evidently impossible to distinguish between the fissuration of these bodies as yolk cells, and the same operation when they have become the cells of which alone the embryo is composed, at the age to which we have just traced them; for, in the latter case, they have still the same more or less dark, oily outline, with some, here and there, containing one or two waxy bodies, (fig. 5a, 8,) entoblasts. By the time, however, that the primitive stripe (Pl. 11, fig. 3, *b*) has begun to form, this heterogeneous aspect has disappeared; and the mesoblasts, the primitive embryonic cells, —as we may now call them, in reference to their being the original constituents of the embryo,—are of a nearly uniform size (Pl. 9a, fig. 34, *a*) throughout the upper surface of the young animal, and the exterior of the germinal layer.

Here we have, at last, an indisputable series of facts, the succession of which is unbroken, showing the origin and nature of what constitutes the primitive cellular basis of the germ. These facts are enough to establish the identity of the segmented mesoblasts of yolk cells with those cells which are primarily arranged surface to surface to build up the embryo. There is now no room left for the supposition that the Purkinjean vesicle takes a part in the operation.[1] The idea is negatived without directly referring anew to the mode of development and the final disappearance of that vesicle, when it can be shown, as we have just done, that the embryonic disc is entirely composed of yolk-cell mesoblasts after their most minute self-division. Any further account that may be given of the ulterior changes of these cells belongs more properly to that section which treats of the structure of the tissues, the histology, of the various organs.

[1] We have already alluded to the exaggerated importance which has been ascribed to the germinative vesicle, and to the erroneous impression conveyed by its name (p. 481, note 2, and p. 463, note 1). After what has been shown in this section respecting the origin of the primitive embryonic cells, we may fairly add, that it is now proved that the Purkinjean vesicle takes no part in the formation of the embryo, beyond supplying the region in which it originates, as a distinct body, with a larger quantity of albumen than is found in other parts of the egg. The whole process thus appears like a succession of isolations and recombinations of the oleaginous and albuminous substance of which the yolk is composed, with a prevalence of the albumen at one pole of the egg, where the embryonic disc arises, and a more extensive accumulation of the oleaginous mass at the other pole, where the so-called vegetative systems of organs originate.

SECTION V.

SEGMENTATION OF THE YOLK.

The morning of the 27th of May, 1854, was made memorable to us, in our investigation of the embryology of Testudinata, by the discovery of the segmentation of the yolk in eggs of Glyptemys insculpta. After repeated trials every day for the space of several weeks upon Chrysemys picta, Nanemys guttata, Ozotheca odorata, Chelydra serpentina, and Cistudo virginea, — which were opened in great numbers, sometimes a little too soon, when the eggs were still in the ovary but just about to drop from it into the oviduct, or again too late, when the embryonic area had already obtained its definite outline and smooth, uniform surface, — it seems rather singular, that a species which is comparatively rare should have furnished the information so long looked for.

From what was seen in the oviducts of one of these animals, it is evident that the segmentation of the yolk proceeds very rapidly, indeed so rapidly, that the space of twenty-four hours probably covers the greater extent of this process. Of three animals opened in three successive days, the first furnished eggs, on the 27th of May, exhibiting the earliest stages of segmentation thus far observed in Turtles (Pl. 10, fig. 1–8); the second, on the 28th of May, gave those in which segmentation was almost completed (Pl. 10, fig. 9–11b); and the third, on the 29th of May, contained only eggs with well defined embryonic discs (Pl. 10, fig. 15, 15a). After all, we were not favored with the view of a primitive furrow, dividing the yolk into two equal portions. There is even good cause to doubt that the yolk always commences segmenting in such a regular manner, if we may judge from the total absence of bilateral symmetry in some of the early stages of this phase (Pl. 10, fig. 5, 6, 7) in the development of the egg. The youngest and simplest form of segmentation was observed in the most anterior of three eggs, in the right oviduct. About midway between the two ends of the yolk mass, which was already elongated, — as in fig. 1 and 1a, which represent a similar but somewhat older state, — and parallel to its longer axis, there ran a straight, narrow, and deep furrow, (Pl. 10, fig. 3,) with rounded edges, broadening at each end, and shallowing to a level with the surface of the more eccentric segments. Altogether this furrow equalled in length a little more than one fifth of the longitudinal diameter of the vitelline mass. (Compare fig. 1a. to see the natural size.) Commencing at two points, a little more than one third the distance from the ends of the first furrow, other furrows of a similar nature but only about half as long extended laterally and obliquely outward, one on each side of the several points of departure, so as to include between themselves and the terminal thirds of the main furrow, equilateral, triangular spaces, and on each side of the median third a truncated isosceles triangle, each of which was partially split, as it were, by a short depression, originating from the central part of the principal furrow, and terminating sharply at its ends. Thus, on the whole, six segment masses, two of which were again partially divided, were included in the formation of the embryonic area at this early stage. The depth of these furrows was not ascertained in a definite manner; yet, judging from appearances and the known thickness of this portion of the germinal layer, they must have penetrated very nearly, if not fully, to the inner surface of the latter.

In another egg, a little older, and the anterior of four in the left oviduct, the main furrow was not parallel to the longer axis of the egg, running more in a zigzag line, (Pl. 10, fig. 2,) and the lateral oblique furrows trending so as to be more nearly perpendicular to the longer axis of the yolk. Those which terminated sharply in the last egg were here represented by much more lengthened forms, and not exactly symmetrical as to their point of origin as in the former eggs, being nearer to the end of the principal furrow on one side than on the other. So, even at this early period, there is here a considerable want of bilateral symmetry, which still further justifies the doubt, already expressed, as to the constancy of a single furrow, in the beginning of the segmentation. It will also be noticed, that there is some difference in the two figures which are given of this stage from the same egg (Pl. 10, fig. 1 and 2); but this apparent disparity is explained by the circumstance that one view is more superficial than the other; the one (Pl. 10, fig. 1 and 1a) representing only the surface of the embryonic area where the outermost edges of the segment masses more or less overlap each other, and the other (Pl. 10, fig. 2) a deeper view, through the overlapping edges just mentioned: thus showing that the furrows are not perpendicular chasms, but bend, some in one direction and some in another, opening below, in one instance, (Pl. 10, fig. 2, *b*,) in a line at right angles to the main furrow, but gaping above, (Pl. 10, fig. 1, *b*,) with edges running quite obliquely to it, or, as in the case of the median transverse furrows, opening above (Pl. 10. fig. 1) in one and the same line, and terminating differently one from the other below (Pl. 10, fig. 2). This obliquity becomes more and more evident as the number of segment masses increases, and their contours attain a more rounded outline, just as would happen were a collection of plastic, rounded bodies pressed against each other as they laid spread out upon a convex surface. The embryonic area of the egg next behind the one first mentioned (Pl. 10, fig. 3) was hardly older than the second one, (Pl. 10, fig. 1 and 2,) but much more irregular, (Pl. 10, fig. 4,) evincing a great want of symmetry in the origin of the transverse lateral furrows, so much so that on one side a small segment mass had become totally isolated by a circumvallation.

The embryonic area of the three following eggs, two of which were from the left (Pl. 10, fig. 6 and 7) and one from the right (fig. 5) oviduct, exhibited about the same degree of advancement: all agreed in being very irregular in their segmentation, and in having most of their furrows more or less transverse to the longer axis of the yolk, without any trace of the principal furrow observed in the younger stages. Centrally each possessed two or three isolated masses, and others more or less completely separated. It would be almost a needless repetition, after what has already been shown, to insist here upon the centrifugal character of this process, as the first isolated masses originate always at the centre of the embryonic layer, and those which appear afterwards are successively further and further out of the centre. This is more particularly noticeable in another embryonic area, (Pl. 10, fig. 8,) the fourth and last in the left oviduct of the same animal, which is still further segmented, and in which the furrows radiate from a centre occupied by five isolated masses, while the cone-like portions included by these furrows are more or less rounded off at their summits. In this same egg, too, we may observe the diversity in size at which the masses originate, two or three being much smaller than some others, that are more central.

On the 28th of May another Turtle was opened, and, as already stated, the eggs were found in a very advanced state of segmentation, yet not so far beyond those of the first animal opened the day before as to break the link of connection with them. The segmentation had already extended over a much larger extent than the furrows of the embryonic areas observed the day before had included, and the now numerous radiating cones diverged from a field still more distant from the centre (Pl. 10, fig. 9, 10, 11, 11a, 11b). Of four embryonic areas in this condition, that in the oldest egg, (Pl. 10, fig. 9,) the fourth and most posterior in the right oviduct, was the least evenly segmented; the centre being still occupied by several masses larger than those embraced in the same region in the other three. However, all four agreed with each other in having the most minute masses in the centre, and the larger ones at the circumference. But the furrowing had not altogether taken place in a perpendicular direction, as we may see by a glance at one of the more magnified views, (Pl. 10, fig. 11,) where the masses are heaped one upon the other in such a manner as unmistakably to evince a horizontal fissuration, such as was partially approximated in the oblique chasms of the earliest segmentation (Pl. 10, fig.

1 and 2). The embryonic area of the egg next to that of fig. 9 in the right oviduct was the most minutely segmented (fig. 11b); the one next to it in this respect (fig. 11) was, on the contrary, the most anterior in the same oviduct, whilst another, (Pl. 10, fig. 9,) intermediate in position, in the oviduct of the same side, consisted of coarser masses than the two preceding; and the youngest (Pl. 10, fig. 10) was second from the front, in the left oviduct. This shows distinctly that the progress of segmentation does not correspond to the age of the eggs.

It is to be regretted that the opportunity was missed of making special investigations as to the nature of the substance which held together the components of the segment masses, and that it was not ascertained from the living egg whether a membrane was formed around each of these masses, as their smooth exterior would lead one to suppose, or whether they were merely enveloped in the albuminous fluid that had already begun to be absorbed from the outside through the yolk sac. After some researches upon this subject, made subsequently upon carefully preserved alcoholic specimens, we are very much inclined toward the latter view. It is true, the altering effects of the preserving fluid may be objected to; but this much we may say in favor of this opinion, that, in the specimens examined, the ectoblasts of that portion of the yolk which was not yet fissurated, at the lower side of the egg, although of excessive tenuity and tenderness, were in many instances nearly as distinct as ever, excepting a slight wrinkling or flattening by contact with each other, and that the mesoblasts, which are so susceptible of change in a fluid not natural to them, were in this instance very often entirely unchanged. Now, under such favorable circumstances it is quite reasonable to expect that a membrane of tolerable consistency would still be found, if it ever existed, around the segment masses; but, after prolonged search, not the least trace of any such membrane could be discovered. In fact, all indications of furrows had disappeared; and only very faint remnants of heaps among the cells broke the homogeneity of the embryonic area. In all probability the alcohol had dissipated the albumino-oleaginous, glairy substance that inclosed the masses. But, even supposing that such a membrane had been present for a time, it certainly disappears in the natural course of the changes which the vitellus undergoes, since nothing of the kind existed in well defined embryonic discs, where the segmentation had gone through its phases till no two cells were left together. This has been specially noted in the description of the progress of the self-division of the mesoblast.[1]

Under a low magnifying power, some of the larger masses of the embryonic

[1] Compare p. 521.

area may be seen undergoing further segmentation, (Pl. 10, fig. 11,) either by single furrows or by two or three or four or more; and beyond these the cone-shaped bodies radiating around its periphery appear in the act of extending their longitudinal division, and throwing off masses from their apex by transverse constrictions (fig. 9, a^1, and 11, a^1). We would ask particular attention to these cone-shaped, radiating bodies, as hereafter they will have a special bearing upon the question of the extent of segmentation over the area of the germinal layer. From the earliest stages of segmentation, up to the time when the embryonic disc is perfectly formed and well defined, a yellowish white color pervades its surface; but it becomes more yellow outside of the circumscribed area, where the thinner germinal layer allows the yolk to shine through.

Comparing the size of a smooth and sharply defined embryonic disc, (Pl. 10, fig. 15, 15a,) found in an animal opened on the 29th of May, with that of some of the preceding eggs, (fig. 11b,) it appears that here segmentation must have already progressed beyond the boundaries of the embryonic disc, and encroached upon the space devoted to the vascular area. This assertion is borne out, not only by the presence of the above-mentioned cone-like bodies outside of the embryonic disc of an egg from another species (Nanemys guttata) with well marked boundaries, and encircled by a clear, transparent, narrow ring, the area pellucida, (Pl. 10, fig. 12, a^1 and 13,) but also by the presence, in a similar position, of large numbers of rounded segment masses, (fig. 14, *c*, *c*,) in the egg of Chrysemys picta. There is no chance here to mistake the relation of the parts; and it cannot be doubted, therefore, that segmentation does not belong exclusively to the embryonic disc, but extends also, for a certain distance, to the surface exterior to it. Of this we have ocular evidence; but whatsoever reason there may be to believe that it goes on beyond this must be based upon induction; and yet, even here, to any one who has followed the series of preparatory steps through which the yolk passes in this region, and has noted the peculiar physiognomy which it bears when thus specialized, in a certain manner proper to itself, all over the surface of the vitelline mass, the almost certain conviction arises, that segmentation must spread over any surface to which this layer extends, and to whatever depth it may eventually plunge, even though, in the end, it included the whole bulk of the yolk.

It may seem an unwarrantable inference from premises of insufficient weight to assert the belief, that, in Testudinata, the whole egg undergoes segmentation, and not the surface only, at a definite point. This much, however, is certain: this process goes on, to a known extent, in the region of the vascular area. But what is the final expanse of this area? It is not limited within a certain circle to the surface of the yolk only; it spreads eventually all over the latter, and, still later, plunges into its substance, till the whole yolk mass becomes a great network of bloodvessels, (Pl. 18, fig. 4,) a vascular area, hollowed out in the lamellar partitions (Pl. 17, fig. 1) into which the yolk cells have consolidated themselves. Now if segmentation obtains in a part of the vascular area, and is still apparently progressing externally, it is at least reasonable to expect to find it operating eventually wherever that area may exist; especially as the latter bears with it the identical uniform arrangement and modifications of yolk cells which are found within the circle of its primary development. So confident are we of the soundness of this theory, that we look earnestly forward to another breeding season for an opportunity to demonstrate it in an indisputable series of ocular proofs.

SECTION VI.

THE WHOLE EGG IS THE EMBRYO.

Since we have shown in former pages, that the embryonic disc, and its extension, the germinal layer, are formed by the original apposition of yolk-cell mesoblasts minutely subdivided, and that these yolk cells are all the same through the whole yolk mass from centre to surface, even to the very walls of the superficial Purkinjean vesicle; and, moreover, since it is proved that segmentation obtains beyond the embryonic disc, and very probably all over and throughout the whole yolk, it is evident, that, in the egg of the Testudinata at least, the region around the Purkinjean vesicle cannot be separated from the more exterior or inferior mass which constitutes the greater bulk of the vitelline substance, and that the last cannot be homologous to the contents of the Graafian follicle,[1] which bears no part whatever in the formation of the embryo, but is totally exterior to the mammalian egg. Again, as will be shown hereafter, that portion of the yolk which is originally excluded from the primary circumscription of the outlines of the embryonic disc cannot be separated from the animal as an appendage,[2] for it very soon

[1] Meckel von Hemsbach (Zeitschrift für Wissenschaft. Zool.) and Thompson (Cyclop. Anat., London, 1854, article "Ovum," page 77) deny that the whole yolk mass of the Birds and of the scaly Reptiles corresponds to the egg of Mammals. The first of these writers compares the Purkinjean vesicle alone to the mammalian ovum, and the yolk surrounding this vesicle to the corpus luteum; whilst the latter author includes the granular cicatricula, along with the vesicle imbedded in it, as homologous to the mammalian egg, and the yellow yolk to the tunica granulosa of the Graafian follicle. With this latter view Dr. Martin Barry (Phil. Trans., London, 1839, p. 309, note, and 370) is strongly inclined to coincide.

[2] It has been customary heretofore, among most authors, to designate the yolk sac as a reservoir of

afterward becomes an essential part of the "embryo," as the latter extends itself in the form of a germinal layer and a vascular area, not only all over the surface of the yolk, but, in the case of the area vasculosa, through the whole vitelline mass, the latter becoming a great spongy network of bloodvessels, formed by the lateral apposition of the cells composing this large body. This vascular mass is finally drawn into the body, and, though gradually disappearing by resorption, remains for nearly six months after birth, as one of the essential portions of the organization of the freely moving animal.

Because a part is more or less separated from the main body, it does not follow that it should be considered as an appendage or an unessential portion of its structure. The bladder, at one time, hangs out in a saccular form as an allantois, extending far beyond its subsequent relations, and yet it is an organ of the embryo. No one would deny that the legs are an integral part of an animal because they extend beyond the bulk of the body; no one would hold that the young teeth, which, after a certain age, are discharged from their capsule, were not essentially a part of the body because they eventually disappear; no one would assert that the menses are not a characteristic physiological phenomenon of the animal system because they cease at a certain age; or that the ovaries, because they are resorbed at this period, were mere transient accessories of the organization. As if life were ever at a stand-still, a stereotyped machine, hewed and hammered out and put up to perform a certain uniform work, never changing from the time it is built till it falls to pieces by wear and decay! No; not so. We may truly say that life is embryonic all through; embryonic, in the sense that changes go on in the adult as in the young, and oftentimes quite as extensively as in the unborn or just born animal. From the moment that the egg is isolated, a new individual life commences; the animal potentially exists. Nor are we by any means to suppose, that the yolk, because it floats freely for a while, is a mere vitelline substance, and not an integral part of the embryo. Does not the blood float freely in the adult body? and does it not originate in the embryo as a loosened mass of yolk-cell mesoblasts, (Pl. 19, fig. 6,) separated from the sides of the channels, which, after having been hollowed out in the thickness of the intestinal layer, form bloodvessels? And yet, who will deny that this fluid

nutritive substance, in contradistinction to the "embryo," which is placed above it, the latter increasing in size as the former supplies the materials. (Comp. Part. I., Sect. 1, p. 181, and Sect. 6, p. 229.) This, we will admit, is true; but only in the same sense that the stomach, as an independent organ of the body, bears the means of existence to the whole organism. In both cases the nourishment is taken up by vessels through the process of endosmosis. The yolk is never appropriated by a process of digestion. There was a time in the history of Embryology when the terms "egg" and "embryo" were synonymous; we have to go back to it, now that we know how gradually the egg is transformed into a distinct embryo.

is part and parcel of the animal system? Then come a series of changes and metamorphoses, at some of which one type stops, while another passes on. One type undergoes certain changes before it is born, another not till a longer or shorter time after birth; one type retains a certain peculiarity of organization for almost its whole lifetime, and this organization forms one of its principal characteristics, while in another, the same peculiarity, lasting but a short time, is too often looked upon as a mere scaffolding and prop-work, which serves to hold the structure in shape while it is perfecting. Because one has a long and the other a short existence, the same characteristics in two different animals are very differently estimated. Minutely described in the first case, they are perhaps totally ignored in the other as unessential, as having no particular reference to the type in which they occur.

Can this be? Is it not true, that each and every type undergoes a series of changes, not only during its "embryonic period," but throughout life; some following after longer, and others after shorter, spaces of time, so that their peculiarity and periodicity characterize this, or that, or the several different types, as distinct from one another? Different animals shed their teeth at diverse ages, and then acquire other habits. Some shed their epidermis (dandruff, scales, feathers, or slough) at stated periods, and others constantly. Some bear young soon after they are born, and others at two, three, ten, fifteen, twenty or more years of age, and this function ceases in them at diverse ages. And yet this latter change is a normal development just as truly as any which occurs at a much younger age. The long space of time that may follow the period of sterility is quite as prominent a characteristic of the life of an animal as any preceding state. At that period, so great a revolution takes place in the system as sometimes to endanger life when adaptation to its requirements is accidentally prevented. Yet, after such metamorphoses, are not the peculiarities of the functions of some of the organs greatly changed? And so we might go on, enumerating many other progressions and alterations, to show, that life after birth is not fixed to one uniform phase; but that there is a constant and more or less frequent formation and suppression of functions, and a series of alterations going on in the organization, not only from the beginning to the end of the embryonic period, but ever afterwards, through the whole duration of life, till death.

Finally, we must contend that it is a false idea of the physiology of animal life to suppose that in the egg the animated being is only forming; that its organs are only combining with each other in order to establish regular communications between them for certain ends, and to prepare the way for a variety of functions, the beginning of which is not realized until a definite and unvarying relation of parts with definite proportions has been completed. As if the heart of Vertebrates, while a simple, straight tube,—without even smooth internal walls, and while the yolk cells are still dropping from its sides into its cavity and only move backwards and forwards like an advancing and retreating tide,—were not functionally and typically as fully a heart as later, when it has obtained two chambers in Fishes, three in Reptiles, and four in Birds and Mammals; or the lungs, while a simple, cul-de-sac-like dilatation of the wall of the œsophagus, were not truly performing their part as well as in the Fish when they become more isolated as a swimming bladder, or in Lepidosteus when they approach the complicated structure exhibited in Saurians and Chelonians, or in the latter two when they occupy a great portion of the cavity of the body, or in Mammals when they have changed into a uniform, spongy mass of minute bronchioles with their capillaries. And so we might mention the progressive stages of the eye, the ear, the brain, and all the other organs, if so many examples were necessary.

At no time is the whole type exemplified by any particular specimen; nor does any one individual, at the moment when we look at it, reveal to us its whole life. Still less can any alcoholic preparation of an animal, as it hangs inanimate before us, disclose its action, its manner of life, its physical relations, its former embryonic simplicity, its later metamorphoses, or its final mode of passing away. Such objects ought only to be considered as means for our study, as memorials of past life. We collect them, that they may assist us in telling the tale of their organic connections. We may even substitute wax models for the things themselves, and that too with very good success, so far as a plastic substance may represent the appearance of animal life at a given period; but the wax is a perfect blank as regards the past or the future, and so is the dead animal, when compared to what it has been, or to what it might have become. But when alive, we see in it at the beginning, as an embryo, certain characteristics of its type; when born it exhibits other characteristics, some of the former disappearing, and some remaining throughout life, and again at various periods of its life other characters appear and disappear, so that some individuals, dying before a certain age, never wholly exemplify their whole type, whether it be that of branch, class, order, family, genus, or species.

When such views are adopted, and such interpretations have become our standards, it is impossible to hold longer to the inanimate nature of any one portion of a growing body, and consider the others as endowed with all the characteristics of an animate being: it is impossible to assert, if we may revert more specially to what has already been said, that the so-called yolk sac is a mere bag of nourishment, a reservoir of food, for the embryo, which increases in bulk as the former doles out its supplies. What part this organ plays in the progress of the growth of Testudinata will be fully described in a future section; let it suffice here to say, that it will there be found to bear a relation to the body and the whole system different from that which has usually been supposed or admitted. When we look at the cellular tissue of the lower branches of the animal kingdom loosely strung together, where we may see every cell of a muscle dilate and contract for itself; where, in the younger but free stages of the same, these cells hardly touch each other, and yet dilate and contract; where the whole animal moves from place to place by the help of these selfsame active vesicles; or where, in the simplest phases of organic structures, we may actually count the number of cells of which the body is composed, as the animal flutters and quivers while falling to pieces before our eyes; — when we see all these phenomena, we need not fear to adopt views contrary to a sound physiology in advocating the animality of the yolk,[1] notwithstanding the loose connection of its

[1] We need only refer to the researches of BISCHOFF, upon the Embryology of Mammals (Entwickelungsgeschichte des Kaninchen-Eies, q. p. 83: p. 93, pl. 8, fig. 40 D, and pl. 16) — BAER, upon Birds (Uber Entwickelungsgeschichte der Thiere, q. p. 67: Erster Theil, p. 67, pl. 1, 2, p^1, r^1, t, u, s^1, q^1) — REMAK, upon Batrachians (Untersuchungen über die Entwickelung der Wirbelthiere, q. p. 83: p. 81, pl. 10, fig. 1–5, pl. 12, fig. 1–8) — VOGT, upon Fishes (Embryologie des Salmones, in Agassiz Histoire naturelle des Poissons d' eau douce de l' Europe centrale, q. p. 81: vol. 1, p. 38, pl. 5, fig. 116–120) — KÖLLIKER and ZADDACH, upon Insects (Kölliker, Observationes de prima Insectorum Genesi, q. p. 80: p. 3, sect. 4, pl. 1, fig. ii., 1, 3, p. 12, sect. 18, pl. 2, fig. ii., 1, 3; Zaddach, Untersuchungen über die Entwickelung und den Bau der Gliederthiere, q. p. 80: I. Heft., p. 3 and 4, sect. 2 and 3, pl. 1, fig. 2, 3, and 4, C, fig. 5, K) — RATHKE, upon Crustacea (Zur Morphologie, Reisbemerkungen, q. p. 79: p. 74 and 75, fig. 9, 10, 11) — MILNE-EDWARDS, upon Annelides (Recherches anat. et zool., q. p. 92: première partie, p. 34–36, fig. 47–50) — KÖLLIKER, upon Cephalopoda (Entwickelungsgeschichte der Cephalopoden, q. p. 74: p. 165, pl. vi., fig. lx.–lxiii.) — GEGENBAUER and LEYDIG, upon Gasteropoda (Leydig, in Zeitschrift fur Wissenschaftliche Zoölogie, q. p. 73: p. 130, pl. xi. fig. 5–8: Gegenbauer Untersuchungen über Pteropoden und Heteropoden, q. p. 74: p. 66, pl. iii., fig. 9–13, and p. 179, pl. viii., fig. 3–9) — QUATREFAGES, upon Acephala (Annales des Sciences Naturelles, 1839, tome xi., p. 208–215, pl. 9, fig. 16–26) — DERBES, upon Echinodermata (Annales des Sc. Nat., 1847, tome 8, p. 90–92, pl. 5, fig. 6–14) — SIEBOLD, upon Medusa (Neueste Schriften der Naturforschenden Gesellschaft in Danzig, 1839, p. 22–29, sect. 14–28, pl. 1, fig. 12–19), — and a host of other authors, quoted in connection with a former section, (see p. 68–87,) to furnish abundant evidence of the truly internal position of the yolk. This part of the egg is, from the beginning, embodied within the extended layers of the embryo, "the germinal layer." In some instances it even assumes very early an organic form, (see Remak, loc. cit., pl. 10, fig. 19–23, dk, and dk, pl. 12, fig. 10, dk; Dr. J. Wyman on the Surinam Toad, Sill. Journ., May. 1854, p. 371, fig. 3; Leydig, loc. cit., fig. 8–12, b, c, d, g; Milne-Edwards, loc. cit., p. 24–26, pl. 1, fig. 8–11,) although its components are quite loosely attached to each other. It may be said that the extension of the germinal layer around the whole yolk mass does not sufficiently imply the identity of the latter with the rest of the embryo; yet, when we see this same mass take the form of an important organ, especially well marked in the Surinam Toad, (Pipa americana.) and so ably described in Wyman's investigations upon this animal, in which the whole yolk is shaped into a spiral intestine, there is no longer any reason to resist the conclusion, that this portion of the living mass is as fully subject to that plastic power which

cells among each other, and their resemblance to those of an unfecundated egg, provided we are aware that the changes which it undergoes in its earlier growth essentially belong to a period anterior to the final influence fecundation has upon its development.

As soon as it is once admitted that the so-called nutritive yolk, as contrasted with the embryo, is an essential part of the embryo itself, there is no longer any possibility of tracing a distinction between an embryo, as it stands out from the yolk at a later period, and the yolk, as embryo, before any morphological difference is introduced between the two, their differentiation being clearly the result of a continuous process, initiated very early in the youngest ovarian eggs prior to the first copulation. It follows, therefore, that the egg itself is, in the strictest sense of its physiological importance, a new being, an embryo, originating in the ovary as a single, specific cell; and that, from its earliest appearance, it is to be considered as the new animal in progress of formation. From this point of view, the names egg, embryo, young and adult animal, are only convenient appellations to indicate the different periods of growth of one and the same being.

Thus far, we have limited our remarks to facts which are within the reach of our investigations. But the inquiring mind is unwilling to stop at the limits assigned to its progress by the circumstances of the moment. May we not ask, therefore, what takes place at the time when an egg, the germ of a new being, originates? Apparently it is only a concentration of an exceedingly small mass of oleagino-albuminous substance, in the form of a sphere. But, in reality, it must be a very different thing; for that sphere is, from the beginning, the centre of an action that differs from the functions going on in any other part of the parental organism. It is alive, and at once proceeds to develop, in a regular manner, towards a definite end. From the beginning it assimilates to itself, and for its own ends, the material supplies it receives from without. Whatever may be said to the contrary, a principle of life is now at work in the egg which is totally

shapes the layers of its more superior portions into the cerebro-spinal systems of organs of the body, as any other portion; or that it is in fact an organ in progress of development, and more or less permanent, according to the animal in which it originates. Indeed, we are inclined to believe, that, upon further investigation, this portion of the body will be found never to disappear entirely, but only to assume successively various guises, either diminishing its bulk and rotundity and lengthening out into the intestine, as in Mammals, Birds, and the scaly Reptiles,—or, as happens in some Batrachians, according to Wyman, coiling very early into an intestine,—or, as Remak has shown in Rana esculenta, moulding itself at first into a thick cylindrical digestive canal, which subsequently lengthens and becomes coiled at the expense of its own thickness,—or simply lengthening, and at the same time diminishing its transverse diameter, as in Abramis (Cyprinus) Blicca (Baer, Entwickel. der Fische, etc., q. p. 81: fig. 9–20.)

different from the chemical or physical properties of its constitutive elements. But what is that principle? It is the same something which distinguishes the parent, as an individual, from every other individual; for that immeasurably small egg grows to be another individual of the same kind, and never produces any thing else. It is the result of an organic impulse, acting as we see thought act in another sphere, when, in consequence of the utterance of a new view or a new truth, a new social organization is called into existence. As truly as the mind of man acts beyond the sphere of its organic functions when it pours forth its conceptions, so truly is the principle of life, characteristic of any parent being, transmitted to the egg when a new individual begins to grow. The comparison may be carried further. The results of the mental activity of one individual may be modified or stimulated by the action of other minds; as the progress of a new individual is modified by the different parts which the parents take in its formation. So the growth of the egg, begun prior to fecundation, is influenced by that act in a manner similar to the development of an idea which is modified by the influence of other ideas. We feel justified, therefore, in saying, that conception and fecundation must be, in a measure, intellectual acts, in however instinctive a way they may be accomplished.

SECTION VII.

FOLDINGS OF THE EMBRYONIC DISC.

In a former section of this chapter,[1] in which are investigated the changes through which the yolk of the fecundated egg passes, it has been shown, that the cells of which this body is composed undergo a series of transformations, ending with their embodiment in the embryonic disc, where each segment of the self-dividing mesoblasts becomes individually a component part of the future cellular tissue. In a succeeding section,[2] the segmentation of the yolk was traced till this process terminated in shaping out a well-defined disc upon one side of the egg, though its further effects extend to a much greater area, if not all over the surface of the egg.

We will now consider the development of the embryo from a different point of view. This well-defined disc, the so-called "embryonic disc," marks the place where the earliest and the most important organs of the animal originate. It is

[1] See Sect. 4, p. 516.

[2] See Sect. 5, p. 523.

within its outlines, and there only, that, in the order of Testudinata, the characteristic features of the type of Vertebrates are developed. From the beginning, the mode of formation and growth of this disc distinguishes the Turtles from the five lower classes of this type which have neither amnios nor allantois, namely, the Myzontes, the Bony Fishes, the Ganoids, the Selachians, and the Amphibians,[1] though they belong to the same branch of the animal kingdom to which the order of Testudinata also belongs. Among the classes just mentioned, nothing like an amnios or allantois occurs, and the embryonic disc bears also different relations to the other parts of the egg. Thus we see, that, at the outset, this order exhibits characteristic features, distinguishing it from the classes below it, and showing its relation to the other orders of its class, and to the classes above it.

Though prevailing universally, it is a mistaken view that the outlines of the embryonic disc are the boundaries of the animal, and that the yolk beyond and below is a mere appendage to it. We have already endeavored to show the fallacy of this theory in a former section,[2] where it has been shown that the whole egg is, even from its first appearance, just as truly the animal as that part of the egg which is circumscribed within the region of the embryonic disc, when this disc becomes distinct from the rest of the yolk. We shall, therefore, speak hereafter of the whole egg as being the animal, and of those portions of the egg which are called the embryonic disc, the embryo, the amnios, the allantois, the vascular area, the area pellucida, the yolk mass, etc., as being so many different organs, or groups of organs, of one great organism. What we have said in a former section warrants us in the belief that we have taken the proper view of this subject; and, under these impressions, we will now proceed to investigate the formation, growth, and changes of the various organs which characterize this type of the vertebrate series. For obvious reasons we will begin with the embryonic disc, as definite organization first makes its appearance there.

The Embryonic Disc. The area over which the embryonic disc extends is not so much marked by peculiarities of its own, as by the circular furrow (Pl. 10 fig. 14, *a*) of the germinal layer, which lies immediately beyond it; although it is true that between the two there is a slight difference in thickness, and in the intimate nature of their cellular constituents. However, the prominent feature that separates these two regions from each other is this intermediate furrow, which, as will soon be seen, is of great significance in relation to the development of an important organ, the amnios. The arching of the embryonic disc, like a blister on the surface of the yolk, renders the yellow color of the latter less visible, and the whiteness of the former more prominent. In some instances, the formation of

[1] See p. 187.

[2] See Sect. 6, p. 528.

the organs within the embryonic disc begins (Pl. 11, fig. 1, a^1) before its outlines are well marked by the deepening of the circular furrow. However, we may mention that it is usually the fact that the embryonic disc becomes sharply bounded before any change comes over it.

By the time the embryonic disc has become well defined, (Pl. 10, fig. 12–15,) there is already a difference noticeable in the nature of the cellular components of its upper and of its lower side. Those above are by far more uniform in size, and smaller (Pl. 9a, fig. 34, *a*) than those below; they form a thin, uninterrupted layer (Pl. 9e, fig. 1, *a*) of so smooth a surface as to give to the embryonic disc that polished aspect mentioned before, while those below are coarser and darker, (Pl. 9a, fig. 34, *b*,) still evincing a cumulated arrangement, and, in some instances, even restrained by the parental envelope.[1] These lower cells form by far the thicker layer (Pl. 9e, fig. 1, o^1). The upper layer (*a*) is continued over the whole surface of the yolk; but here it is not quite so thin as on the embryonic disc. The lower layer (o^1) follows the upper, (*a*,) but is not so distinct from the subjacent more mobile yolk mass (*yk*); yet it is sufficiently separated from the yolk to be easily recognizable, even though it forms an intermediate stage between the two. The thinner or upper layer (*a*) more properly deserves the name of germinal layer, and the other, the thicker or lower, may be considered as a subsidiary layer, (o^1,) the upper surface of which is constantly furnishing supplies to the thickness of the upper layer, (*a*,) and is continually added to from below, (*yk*,) for a certain length of time, which varies according to the part of the whole developing mass to which it belongs. We have mentioned before in passing, that, in the vascular area, there is a constant addition to this layer, even up to the end of the period of incubation.

The Amnios. We have already noticed the initial steps toward the formation of the amnios, when pointing out the circular furrow which bounds the embryonic disc. This furrow (Pl. 9e, fig. 1, *c*; Pl. 10, fig. 12, 13, 14, *a*, 15) is not formed by a scooping out of the thickness of the germinal layer. It is, on the contrary, the result of an actual depression of its whole thickness (Pl. 9e, fig. 1, *c*, *c*); so that, if viewed from below, that region would appear to have a circular semicylindrical ring raised upon its surface. This is the first indication of the folding of the germinal layer to form the amnios.

But soon this uniformity yields to a different tendency. The edge of the embryonic disc becomes suddenly depressed at one point, so that, viewed from above, it appears as if a narrow segment of a circle had been cut away from its sides (Pl. 11, fig. 1, a^1, 6, a^1). A longitudinal section of the embryonic

[1] See p. 519–522, and Pl. 9a, fig. 7, 9, and 34.

disc (Pl. 11, fig. 6a, and Pl. 9e, fig. 2) shows at once the nature of this change, and at the same time discloses a thickening at the part (Pl. 9e, fig. 2, a^1; Pl. 11, fig. 6a, a^1,) where the depression occurs, and also that the subsidiary layer (Pl. 9e, fig. 2, o^1) follows this depression. By this time the yolk mass has begun to recede from this spot, and is replaced by the albumen which has filtrated through the several walls and layers around the yolk. As yet, however, the albumen (Pl. 11, fig. 1a; Pl. 9e, fig. 2, *al*) occupies but a small segment of the yolk sac. The next older phase has brought the wings of the depression nearer to one another, so that the central part of the latter is bounded, on the side next to the disc, by what resembles a cone confronted by the approximated horns (Pl. 11, fig. 2, a^1) which bounded the formerly lunate hollow. By this time, too, the opposite end (Pl. 11, fig. 2, a^2) of the disc has become considerably depressed, yet not like the other end, (a^1,) but simply by curving down, while keeping its contour outwardly arched; the right and left sides also are slightly folded in, in a downward direction, carrying with them a broad strip of the neighboring space, and thus forming a deep annular depression all round (Pl. 11, fig. 2, *c*).[1]

[1] Among the eggs which were retained in the oviduct by a female in confinement beyond the usual time of laying, we have found some remarkable instances of monstrosity.

We will first mention one found in the egg of Malacoclemmys palustris. As the embryo normally develops, the caudal hood, as just stated, commences to form almost immediately after the cephalic hood, but in the instance before us (Pl. 11, fig. 7, a^2, 7a, a^1, a^2, 7b, a^1, a^2) the head is strongly bent upon itself, whilst the caudal end (fig. 7b, a^2) is not folded in the least. The back of the embryo is also more arched (fig. 7b) than in the normal state.

Another instance, of much more extreme disparity between the two ends of the embryo, was found in the egg of Ozotheca odorata. The embryo, instead of having its normal round or broadly oval form, suddenly narrows behind to half its anterior width, and then terminates in a rounded end (Pl. 11, fig. 9, 9a, 9b). Here again the cephalic hood alone has developed, and that, too, far beyond the bounds of normality. After having bent upon itself as is usual, a portion of the head along the axial line has continued to push still further back in the form of a blind sac, till it has reached the posterior end of the embryo (Pl. 11, fig. 9, 9b). Seen from above, (fig. 9.) the blind sac appears broader behind than at its mouth, and in a longitudinal section (fig. 9b) we see that it is quite flat, and proceeds in a straight line from the head to the tail, and also that the back of the embryo is much more arched than in the preceding case. We have also made a cross section of this embryo, just behind the head, (Pl. 11, fig. 9a,) in order to display the transverse arch of its back and the flatness of the whole width of the blind sac, and the manner in which its mouth expands sideways and joins the more peripheric part of the embryonic disc. It will be noticed in this transverse section (fig. 9a) that the sides of the embryo are rather suddenly bent downwards; but at the caudal end there is no folding, (fig. 9), notwithstanding the highly developed character of the cephalic hood.

In another instance, (Pl. 11, fig. 8, 8a,) the embryo of this same species exhibits the normal oval shape, but otherwise resembles the last in the mode of its development. The blind sac, however, is cylindrical, and does not reach more than three quarters of the way toward the caudal end (fig. 8). At the mouth of the blind sac there is a furrow on its upper side, (fig. 8a,) which might be mistaken for the primitive furrow, but it is probably a longitudinal fold.

In another egg, of Malacoclemmys palustris, the embryo appears, at the first glance, perfectly normal

In consequence of these folds, and owing also to the growing transparency of the annular depression which forms the area pellucida, (Pl. 11, fig. 2, *c*,) the embryo has a very prominent aspect, underlaid as it is by a dark background.

In an immediately succeeding phase, (Pl. 11, fig. 3,) the horns above mentioned are overlapped by the more prominent central cone, (Pl. 11, fig. 3, a^1,) and the depression at the caudal end is quite deep (Pl. 9c, fig. 3, a^2; Pl. 11, fig. 3, a^2) and broad, fully as much so as the cephalic one; the sides also are more depressed (Pl. 9c, fig. 3a, *n*) than before, and the whole embryo is strongly arched, and tapers towards the end where the three conical eminences crowd together (Pl. 11, fig. 3, a^1). Here the lunate depressions (Pl. 11, fig. 3, *c*, *c*) are no longer confined to the width of the original embryonic disc, but extend even to the edge of the area pellucida, so that the latter is divided into four nearly equal portions or fields, namely, two lateral areas, (Pl. 11, fig. 3, a^3–a^4,) slightly sunk, and two deeply depressed ones, (*c*, *c*,) and terminates by a sudden bend (Pl. 9c, fig. 3, *d*, *d*, 3a, *d*, *d*) at the outer edge, where it joins the more peripheric part of the germinal layer (Pl. 11, fig. 3, *d*).[1] The distinctness of these four regions depends upon the greater or less degree of folding of the edge of the embryonic disc, the base of attachment of the amnios. In these last two phases the subsidiary layer (Pl. 9c, fig. 3, *d*, *d*, 3a, *d*, *d*) is not so thick as before, and does not follow so closely the upward curvature (Pl. 9c, fig. 3, *c*, *c*, 3a, *c*, *c*) of the germinal layer, where it extends over the area pellucida; but, stretching outwardly with a long bend, (fig. 3, *d*, 3a, *d*,) leaves a considerable space (c^1, c^1) between itself and the sudden fold of the layer above. This structure, with the thinning of the subsidiary layer and the presence of the infiltrated albumen, accounts for the dark but transparent appearance at this region.

Next, we see the sides of the embryo so folded in (Pl. 11, fig. 4) that the neighboring areas are brought down to a level with those at each end, so that the embryo rests like a dome on a short, broad pedestal in a circular valley. We

(Pl. 11, fig. 10). Like the cephalic hood, the caudal hood is well marked by the sudden bending downwards of the posterior end of the embryo, and the sides of the body also are curved down. However, upon close scrutiny, we find that the cephalic hood has developed just as in the monstrosity of Ozotheca odorata. Here the blind sac is nearly cylindrical (Pl. 11, fig. 10a) and much narrower than that of Ozotheca, but, like the latter, reaches to the caudal end of the embryo, and expands at the mouth like a trumpet. In a longitudinal section (fig. 10b) we see that the blind sac is not so flattened as in Ozotheca, (Pl. 11, fig. 9b,) and that its upper side, nearly touching the highly arched back, follows its curve along the whole length. A view in front (Pl. fig. 10c) shows that the middle of the back is sunk, probably indicating either a fold, or a tendency to form a regular primitive furrow. In all these examples of monstrosity, the clear dark space, the area pellucida, is as normally developed, and appears to be as natural, as in the healthiest embryos at this age. (Compare Pl. 11, fig. 9, and 10, with fig. 2, 3, 4).

[1] In Pl. 11, fig. 3, the letter *a* should be *d*, as in fig. 2.

may mention in passing, that about this time the "primitive stripe" appears upon the *oldest conical* prominence, *(Pl. 11, fig. 3, b,) next to the older* depression *of* the embryonic disc, the cephalic hood; and that the albumen has nearly half filled the space underlying the embryo (Pl. 11, fig. 4a). A few more hours bring about a considerable change (Pl. 11, fig. 5, and 5a): the sides of the embryo are so approximated as to give it the shape of an inverted lyre. The oldest conical prominence has broadened considerably, and is folded under more suddenly; the depression (Pl. 11, fig. 5, a^1, fig. 5a, a^1) of that side is like a narrow, transverse furrow broadened at each end, and that on the opposite side (a^2) has become also deeply lunate by the sharp downward folding of the middle line of the body.

At this time the "primitive stripe" (Pl. 11, fig. 4, *b*) extends along two thirds of the length of that portion of the embryo which is visible outwardly; and below it is represented by a sharp median ridge, (Pl. 11, fig. 5a, *b*; Pl. 9e, fig. 4a, o^1,) which does not belong to the same layer as the primitive stripe, (Pl. 11, fig. 5, *b*,) but is merely forced downwards by its encroachment. The primarily depressed end has become not only much more sunk towards the centre of the yolk mass, but is bent strongly upon itself (Pl. 11, fig. 5a, a^1; Pl. 9e, fig. 4, c^1) and rolled inwardly at the sides, (Pl. 9e, fig. 4a, c^1,) and that portion of the germinal layer which forms the depression now embraces it closely, (Pl. 9e, fig. 4, a^5,) nearly as far up as the level of the exterior surface of the body; but at the opposite end the depression is not so deep, and consequently the upward folding is not as extensive (Pl. 9e, fig. 4, a^2). At this age the embryo hangs over a vast albu*minous mass, (Pl. 9e, fig. 4, al, and* Pl. 11, *fig. 5b, 5c,) occupying more than one* half of the yolk sac, the remaining space of which contains the yolk. The changes which the dimensions of the yolk and of its membranes undergo in consequence of this infiltration of albumen will be fully described in another section.

The next stage in the development reveals which is the head, and which the posterior end, of the embryo. It thus appears that that part of the embryonic disc which is first depressed, (Pl. 11, fig. 1, a^1,) and which, in the last stage, hung so low below the rest of the body, (Pl. 11, fig. 5a, a^1; Pl. 9e, fig. 4, c^1,) is the head, for the development of the brain (Pl. 12, fig. 1a, c^1) is evidently going on here.[1] The fold of the amnios arising from this part is therefore the so-called "cephalic hood," and the other, at the opposite end, the "caudal hood." The amnios, folding backward and upward, and thus far closely following (Pl. 9e. fig. 4, a^1, a^5, a^6) the outer surface of the embryo, has now covered a considerable portion of the head and back,—inclosing the head as with a closely fitting cowl, (Pl. 12, fig. 1a, a^6,) the thickness of which, in profile, resembles a narrow

[1] By mistake in lettering this plate, c^1 was inserted for c^1. A sharp pencil may easily correct this oversight.

ring, and broadening over the back, so far on each side (a^3) as nearly to reach the borders of the now elongately oval area pellucida (c), — while at the other end (Pl. 12, fig. 1a, a^2) it forms a similar covering, (Pl. 9e, fig. 4, a^2,) with a similar appearance in profile, and extending up along the back with a much broader expanse (Pl. 12, fig. 1, a^2) than at the anterior end (a^1). At this time the dorsal vertebræ have become conspicuous to the number of three or four, (Pl. 12, fig. 1, f, and 1a, f,) and the spinal tube (fig. 1a, c–c^1) is closed over for more than half the length of the body. A longitudinal section (Pl. 9d, fig. 1) of the embryo at about this age may assist greatly to explain the manner of folding of the amnios; and here it will be seen that the cephalic portion of this layer does not bend suddenly upon the head and then upwards and backwards, but, after leaving the head, still keeps on for a short distance (Pl. 9d, fig. 1, a^0) toward the posterior end of the body, then duplicating, passes forward and upward along the back to the edge of the upper fold, (Pl. 9d, fig. 1, a^1; Pl. 12, fig. 1, a^1,) where it turns at a sharp angle upon itself and runs forward, sinking considerably as it traverses the area pellucida, (Pl. 9d, fig. 1, c; Pl. 12, fig. 1a, c,) but rising again passes over the whole surface of the yolk. The caudal hood, however, (Pl. 9d, fig. 1, a^2–a^2; Pl. 12, fig. 1a, a^2,) turns abruptly upon the tail, and then, following its curvature backwards, upwards, and for a short distance forwards, bends upon itself just as sharply (Pl. 9d, fig. 1, a^2 above, and Pl. 12, fig. 1, a^2) as the cephalic part, following now backwards its own previous advancing curvature, and, forming a considerable depression (Pl. 9d, fig. 1, c) as in front, finally continues (a) over the peripheric portions of the yolk mass. The lateral portions of the amniotic zone have not yet altogether risen above the lower edge of the body.

In a subsequent and little older phase, (Pl. 12, fig. 2,) it is visible that the anterior or cephalic fold (a^1) incloses the body more rapidly than the caudal one, (a^2,) so as to extend backwards beyond the half a dozen dorsal vertebræ which have now become apparent. The shape of the space that still remains open in the amniotic fold above is variable, inasmuch as it is circular here; whereas in a little older condition (Pl. 12, fig. 3b, a^1, a^2) it is elongately oval; and then again, in a still older instance, it is circular (Pl. 12, fig. 4, a^1). By this time the lateral folds have risen to a level with the surface of the back, (Pl. 12, fig. 3b, a^1, a^2,) and the lower bend of the cephalic hood (Pl. 12, fig. 3, a^0, 3a, a^0) has considerably extended backwards, so as to reach nearly to the middle third of the body. The breadth of this fold, reaching as it does far on each side of the body, indicates that the lateral abdominal edges of the body have not yet folded inwards. What appears to be an anterior fold of the cephalic hood belongs to another layer, namely, the subsidiary layer, which, as we have said before, closely lines the lower side of the *body:*[1] *this layer here follows the bend of the head for a short distance, thus* forming a double layer with the amnios in this region; but suddenly (Pl. 9d, fig. 1, a^3) it leaves the track of the amnios, and, forming an angle, (Pl. 12, fig. 3, a^3, 3a, a^3,) changes its course, passing more directly forward to join the amnios again (Pl. 9d, fig. 1, *d*) on its centrifugal passage after the last bend above.

Soon the amnios ceases to follow the surface of the body, and may be seen forming bridges (Pl. 12, fig. 6, 9, 9a, 10, 10a, 10b) across the sinuses between the prominent portions of the body, evidently under a high tension, if we may judge by the rapidity with which it contracts when cut in these places. This tension is not due to its being filled with fluid, for it is not yet closed over on the back; but the amnios is evidently kept in this state by the curved body striving to straighten out, which it does the moment it is set free from its restraint. By the time the eyes, the ears, a slightly saccular heart, the branchial fissures, a well developed vascular area, and all the vertebræ but those of the tail, have become prominent features of the embryo, the amnios is nearly closed over, (Pl. 12, fig. 10a, a^3, a^4,) by the gradual contraction of the anterior, posterior, and lateral dorsal folds.

Up to this time the body has hung partly supported by the amnios, and partly by the peripheric attachment of the subsidiary layer. In a view from below, (Pl. 12, fig. 10,) the amnios (a^5) appears like a narrow halo extending over the whole length of the body and forms an aperture below, (*o*, *o*,) similar to that above the back; but the sides of the aperture are not yet within the width of this region of the body. There are two peculiarities to be considered in the formation of the amniotic sac. *The first is, that its closing over, above the back, does* not take place along an extended line, but by an approximation of its edges towards a point, around which it gradually contracts, till the stratum that envelops the body is attached to the greater bulk of this membrane by a mere hollow neck, which, finally, is severed by the further constriction and union of the edges of the aperture. As would naturally be expected, as a consequence of this proceeding the outer peripheric portion also closes its aperture, and thus forms a continuous closed sac, lying just within the embryonal membrane, which, as we have already pointed out, follows closely every curve and angle of this layer, and consequently shares in the formation of these double saccular envelopes. The other peculiarity of the amnios is, that its folding upwards and concentrically is totally independent of all pressure from the allantoidian sac, which at the present time has but just begun to develop, though it eventually encroaches upon this region, following closely upon the surface of the already complete amniotic envelope. At the time of this change in the relations of the smaller inner, and the

[1] See p. 536.

larger outer, amniotic sacs, the latter no longer keeping the embryo suspended, this falls on its left side, (Pl. 13, fig. 2,) where it remains till a late period (Pl. 13, 14, 15, 16).

As the embryo increases in age and the body bends more and more upon itself, the amnios gradually follows less and less the contours of the lower side, and reaches across broader sinuses, namely, from the top of the head to the ventral opening, (Pl. 13, fig. 3; Pl. 14, fig. 4, 5; Pl. 18a, fig. 8, a^1; fig. 13, $a,^1$) and from the caudal region to the posterior edge of the same opening (Pl. 13, fig. 2; Pl. 18a, fig. 8, a^2).[1] This separation from the surface, against which it formerly pressed, grows still more conspicuous, and soon the dorsal portion begins to raise itself above the back of the embryo, (Pl. 15, fig. 12,) and then the whole amniotic sac swells out, (Pl. 9c, fig. 3; Pl. 14, fig. 1, 3; Pl. 15, fig. 4, 5, 12; Pl. 18, fig. 9a,) as if distended with fluid, far beyond the outlines of the body, and thus becomes very conspicuous. Here then it is evident, that, at this age, the embryo remains in a curved position, by its own natural tendencies irrespective of its amniotic envelope. The distension of the amnios by the action of the infiltrated fluid would seem to indicate that there is a difference, at least in density, between the latter and that which is exterior to it, outside of the sac; else why should this endosmotic action take place? Unfortunately no investigation of these fluids has been made. Subsequently, in the latter stages of incubation, this distension subsides, and the amnios again closely embraces the body. In this condition it remains till the animal leaves its shell (Pl. 15, fig. 1, 2, 8, 8a, 9, 11; Pl. 18, fig. 10, 10a, 10b, 10c).

Synchronically with the changes described above, the lower opening of the body gradually narrows, and bears along with it the basis of the amnios, till finally the latter is attached to the ventral surface by a narrow isthmus, (Pl. 9c, fig. 3; Pl. 14, fig. 1; Pl. 15, fig. 4, 5, 12; Pl. 16, fig. 5,) springing from the trumpet-shaped abdominal projection.

The peripheric portion of the germinal amniotic layer still persists after its separation from its inner fold, the "amniotic sac," and may be observed even to the latest moment before the period of hatching of the little Turtle. It is recognizable not only by its relation to the other membranes, the embryonal membrane and the allantoidian sac, but also by its characteristic cellular structure, (compare Pl. 9a, fig. 28 with fig. 31, *b*, 31a, *b*,) which will be described in another place, in connection with the histology of the various organs and of other parts of the body.

Growth of the Embryo. Immediately after the first steps are taken to bring out

[1] The largest figure of Pl. 18a marked 2, ought to bear the number 8.

more prominently the growing differentiation of the two opposite portions of the embryonic disc known as the cephalic and the caudal amniotic hoods, in contradistinction to those parts situated between them and at right angles with them, another feature develops itself, under the form of a sharply marked, superficial, short furrow, beginning near the cephalic end, (Pl. 9e, fig. 3, *b*; Pl. 11, fig. 3, *b*,) and trending thence backwards; thus dividing the body into two equal portions, which correspond to the right and left halves of the whole system. The elongation of this furrow continues for some time, (Pl. 11, fig. 4, 5, *b*; Pl. 9e, fig. 4, *b*,) and reaches almost to the caudal end, before any other peculiarity in any way related to its growth appears at the surface. A transverse section of the embryo, at the two periods just mentioned, shows that the longitudinal furrow (Pl. 9e, fig. 3a, *b*, 4a, *b*.) is not a hollowing out of a channel in the depth of the germinal layer, but that the whole thickness of the latter is depressed in the form of a sharp fold, which projects like a ridge on the lower side. But, beneath all this there is an important change going on, which has the closest connection with the furrowing above. In the younger of the two embryos just quoted, (Pl. 11, fig. 3; Pl. 9e, fig. 3, 3a.) at the upper side of the thick subsidiary layer mentioned above, (p. 536,) a broad band of its component, loosely packed, granule-like cells, as thick as the germinal layer above it, has become separated and combined into a more firm stratum, (Pl. 9e, fig. 3, f^1, 3a, f^1,) equalling the length, and following the curve, of the whole embryo, but falling considerably short of the breadth of the same, and only occupying about one third of its whole breadth on each side of the middle line or furrow. The anterior and posterior ends (Pl. 9e, fig. 3, f^1) of this band still remain continuous with its original basis, the subsidiary layer, (Pl. 9e, fig. 3, o^1,) but laterally it is clearly and sharply separated (Pl. 9e, fig. 3a, f^5). It is important to notice, that, in this instance and in others of a similar kind, this proceeding is not a splitting up into thinner membranes of an already well developed cellular tissue, but a secession, a withdrawal of a certain amount of loose, unconnected cells from a larger bed or heap of the same materials. However, inasmuch as these cells are evidently arranged for a certain purpose, we do not intend to deny that there is a determined relation among them, though still in an incipient state.

In the older embryo, noticed above, this broad band still follows the curvature of the lower side of the body, (Pl. 9e, fig. 4, f^1,) which, up to this time, is greatest, and more folded in, at the cephalic end, whilst it has become more extended laterally (fig. 4a, f^1, f^2). Its central axis beneath the furrow appears to be differentiated in structure, since, when seen from below, it presents a sharply defined, narrow strip, having a tint dissimilar from that on each side of it (Pl. 11, fig. 5a, *b*, and Pl. 9e, fig. 4a, *g*). This is doubtless the chorda dorsalis, the relations of which will presently be pointed out more satisfactorily. The subsidiary layer partakes also of the curvatures of the body, following closely its lower surface, as formerly (Pl. 9e, fig. 4 and 4a, *n*, *n*, o^1); but, instead of bending up with the amnios over the head, the sides, and the tail, it extends almost in a direct line (Pl 9e, fig. 4 and 4a, a^3, a^4, and Pl. 11, fig. 5a, a^3) to the outer edge of the area pellucida, (Pl. 9e, fig. 4, *d*, 4a, *d*,) and there, meeting the germino-amniotic layer, (Pl. 9e, fig. 4, *a*, and 4a, *a*,) follows it closely all over the yolk mass. This conduct of the subsidiary layer causes the embryo to appear as if winged, (Pl. 11, fig. 5a, a^3,) when viewed from below. Ever since the albumen began to filtrate into the yolk sac, the subsidiary layer (Pl. 9e, fig. 1, o^1) has been growing thinner; yet not rapidly, but only at such a rate that it is now (Pl. 9e, fig. 4, 4a, o^1) reduced to about three fifths of the thickness it had in the beginning.

Making another advance of from ten to twelve days, we come to an embryo in which the amnios, both in its cephalic and caudal part, has progressed pretty far up, on the back (Pl. 12, fig. 1, a^1, a^2; Pl. 9d, fig. 1, a^1, a^2). The primitive furrow has become a deep channel, (Pl. 12, fig. 1, *c*, 1a, *c*, c^1; Pl. 9d, fig. 1, *c*, c^1,) forming, at the head, quite a large cavity, (Pl. 9d, fig. 1, c^1, c^6,) closed at one point (c^8) by the arching over and uniting of its walls. Along the back, however, this gutter is still open (Pl. 9e, fig. 5, *c*; Pl. 12, fig. 1, *c*; Pl. 24, fig. 13, *c*, fig. 13a, *c*); its lower floor (Pl. 9d, fig. 1, c^7; Pl. 9e, fig. 5, c^7) has broadened, and the whole is curved upwards into a round, cylindrical form, the thickness of which is considerably increased; but its edges, (Pl. 9d, fig. 1, *c*, c^2; Pl. 9e, fig, 5, *c*,) although considerably turned inwardly, remain at a slight distance apart, and are still continuous by a sudden reduplication with the immediate and more peripheric part of this layer, (Pl. 9e, fig. 5, *p*,) which has thickened also, but thins out toward the area pellucida (*c*). At the posterior half of the embryo, this furrow, which may now be recognized as the initiatory phase in the formation of the spinal marrow, and of its enlargement, the brain, has not become so deep nor so narrow, (Pl. 9d, fig. 1, *c*; Pl. 12, fig. 1, *c*; Pl. 24, fig. 13, *c*, 13a, *c*,) but is yet a very broad channel, which gradually grows shallow backwards, and its sides become less elevated, till its lower floor is continuous, in the same horizon, with the space about it; so that a considerable part of the caudal portion (Pl. 9d, fig. 1, c^4) of the embryo is not yet endowed with a special spinal nervous system.

The broad band (Pl. 9e, fig. 3, f^1, fig. 3a, f^1, f^6, etc.) mentioned in former pages, which separates from the subsidiary layer, (o^1,) has now (Pl. 9d, fig. 1, f^1; Pl. 12, fig. 1, f^1; Pl. 24, fig. 13, f^1) become very much thickened centrally, but thins out laterally, and presses closely against the floor of the spinal tube

(Pl. 9d, fig. 1, e^7; Pl. 9e, fig. 5, e^7) and the contiguous portion on each side of it (*p*). At about midway between the head and tail, this band is divided transversely, by four or five fissures, into so many block-like bodies (Pl. 9d, fig. 1, *f*; Pl. 9e, fig. 5, *f*; Pl. 12, fig. 1, *f*, fig. 1a, *f*; Pl. 24, fig. 13, *f*). These blocks are the dorsal vertebræ; and through them we recognize that the "broad band" of former pages is the vertebral layer or basis, from and by which the backbones, constituting the axis of the skeleton, are formed. The chorda dorsalis along its middle portion is now distinctly separated from the vertebral layer, but remains hardly differentiated from the latter at its ends, (Pl. 9d, fig. 1, *g*, g^1,) and may be recognized as a long, cylindrical body, (Pl. 9a, fig. 1, *g*, g^1; Pl. 9e, fig. 5, *g*,) tapering before and behind, lying between the two halves of the broad band, to which it forms an axis. When seen through the thickness of the spinal marrow, this stylet-like body resembles a long and narrow continuous band, (Pl. 9e, fig. 5, *g*–*g*,) bounded on each side by the abutting inner edges (f^2) of the dorsal vertebræ (*f*) mentioned above.

The next lower and more interior layer, the subsidiary layer, (Pl. 9d, fig. 1, *n*; Pl. 9e, fig. 5, *n*,) is separated from those above by a shallow, open space, (Pl. 9d, fig. 1, *h*, j^2; Pl. 9e, fig. 5, j^2,) which extends as far as the length and breadth of the body, and is deeper at the cephalic end, where a considerable portion is almost isolated (Pl. 9d, fig. 1, *h*) from the rest. It will be seen presently that this is of significant importance in relation to the location and development of the system of circulation. The subsidiary layer, which forms the lower floor of this cavity, is thinner than formerly along its middle line, (Pl. 9d, fig. 1, *n*,) excepting at the cephalic end, where it thickens as it follows the backward folding of the germino-amniotic layer (Pl. 9d, fig. 1, a^6). Beyond the outline of the body, however, it thins out again in all directions, and follows for a short distance the amnios as it folds upwards, but soon leaves the same and takes a more direct course (a^3, a^4) to the edge (*d*) of the area pellucida (*c*). At the point where it leaves the cephalic hood to follow its own course forwards, the subsidiary layer makes a rather sudden bend, which, when seen from below, resembles the anterior edge of a broad wing, (Pl. 12, fig. 1a, a^8,) whose posterior edge (a^6) is the line along which the amnios, and along with it the subsidiary layer, projecting from each side of the body, bends upon itself, preparatory to covering the head. In older stages, this is still more prominent (Pl. 12, fig. 3, a^8, a^6, fig. 3a, a^8, a^6).

There is, at this time, beyond the body and for a certain distance (Pl. 9d, fig. 1, from *d* to i^1; Pl. 9e, fig. 5, *d* to i^1) outside of the area pellucida, a dark, clear space of a strongly marked character, and readily recognizable by the naked eye. (Compare Pl. 14, fig. 12, which, although a little older phase, presents to the eye the same appearance.) Upon closer examination of the layers of cells within this space, we find that the subsidiary layer (Pl. 9d, fig. 1, o^1; Pl. 9e, fig. 5, o^1) has undergone a change, both in the closer aggregation and further self-division of its cells, so that it approaches in intimate structure that portion of its expansion (Pl. 9d, fig. 1, *n*; Pl. 9e, fig. 5, *n*) which lines the lower arch of the embryo. The exterior edge of this layer is thickened below, (Pl. 9e, fig. 5, i^1,) so as to present a projecting annular ridge all round. Beyond this, again, the subsidiary layer remains as heretofore.

Another embryo, (Pl. 12, fig. 2,) although two days younger than the last, is considerably more advanced in its development. The amnios is much more closed over, (a^1, a^2,) and the head more sunk towards the centre of the yolk mass. The spinal marrow, for some distance behind the head, has become a closed tube by the uniting of its upward folding edges, (Pl. 9e, fig. 6, *e*,) and its wall (e^7) has increased in thickness. At the posterior third of the body it still remains open, and gradually loses its distinctness from the portion of the germinal layer which extends beyond. That portion of the germinal layer which lies on each side of the part of the spinal marrow that is closed over rests at a lower level than in the last, younger, stage which we have just described, and is considerably increased in thickness, (*p*,) but thins out towards its periphery, till, at its second duplicature (a^2) in the amniotic portion, it suddenly becomes exceedingly tenuous (*a*); and so it remains wherever it may be found beyond the embryonic region.

The figure we have last referred to (Pl. 9e, fig. 6) represents a transverse section of the body at the anterior edge of its posterior third, along a line just behind the point (Pl. 12, fig. 2, a^1) where the amnios is still open. It will be noticed here that the vertebral layer (Pl. 9e, fig. 6, f^1, f^5) is much thinner than in the section of a younger embryo made at the middle region. In the latter case the dorsal vertebræ were already marked out, (Pl. 9d, fig. 1, *f*; Pl. 9e, fig. 5, *f*; Pl. 12, fig. 1, *f*, fig. 1a, *f*,) and so they are in this embryo at the same place, and also much farther backwards; but, as we have shown in very young stages that the vertebral layer grows thinner backwards, so here the same obtains. The posterior ends of the spinal and vertebral layers appear to expand into broad, spatulate figures (Pl. 12, fig. 2); but this is not so much a peculiarity of these strata alone, as a feature arising from the manner of their partial connection with the respective layers from which they take their origin. In both cases, as development defines the position and shape of each, the posterior expansions pass gradually farther and farther backwards (Pl. 12, fig. 3, 3a, 3b, 4, 7, 11, 12, 13). The chorda dorsalis (Pl. 9e, fig. 6, *g*) is large and well marked, appearing darker than the vertebral layer on each side of it, on account of the increased transparency of its cells. The subsidiary layer (Pl. 9e, fig. 6, *n*, o^1) differs in nothing from that of the last embryo, (Pl. 9d, fig. 1,) excepting that it is not separated from the vertebral layer (f^1) by a hollow space; but this arises, as we have shown before, from the inequality in the development of the different organs.

In another embryo, which in some respects is no farther developed than the last, that part of the spinal tube which forms the brain (Pl. 12, fig. 3, e^1, fig. 3a, e^1) is closed over at the most anterior part; but the meeting edges are as yet not obscured, and a slight depression (c^1) remains at the extreme end of the fold, though it does not appear to amount to a passage-way into the brain cavity. The posterior part of the spinal marrow is much more extended backwards than in the last, and narrowed into a distinct band, still open and spreading at the hind end. The dorsal vertebræ are more marked, both externally and by a growing transparency in the centre, (Pl. 12, fig. 3, 3a, 3b,) and the backward extension of the vertebral layer is more defined and distinct from the subsidiary layer. We have already mentioned the wings (Pl. 12, fig. 3, 3a, a^8, a^9) which stand out on each side of the anterior part of the body, but again call the attention of the reader to this point, in order to explain the singular appearance of that region in another embryo, of about the same age (Pl. 12, fig. 4). Here the inequality of position and configuration of the projections that stand out from the body arise from the slight turning of the embryo upon its axis, and the consequent tension of the wings.

In a phase a little farther advanced, (Pl. 12, fig. 7,) in addition to the increased closing over of the tube of the spinal marrow at the posterior end, the farther multiplication of the dorsal vertebræ behind, and the increased backward extension of the anterior edge of the closing over ventral cavity, a new feature appears — a glimpse of which has been given in a younger stage, (Pl. 9d, fig. 1, *h*, j^2; Pl. 9e, fig. 5, j^2) — upon the upper surface of the subsidiary layer, in the form of a broad, transverse band, (Pl. 12, fig. 7, *i*,) connected at its middle with a longitudinal one, (*h*,) which forks (*j*) as it extends towards the head. A closer examination shows that this band is a hollow tube, and contains a movable, granular fluid, indicating the first steps towards the development of the circulatory system. At this time the circulation is not continuous, but moves simply backwards and forwards, in compliance with the impelling force of the periodical contraction and expansion of the longitudinal portion of the tube, (*h*,) which is the heart, without doubt. Beyond the outlines of the body, this figure represents the dark, clear space (*d*) mentioned in a former page, (p. 538,) and also the thickening of its outer edge (i^1) in the subsidiary layer. It will be noticed, that, on each side of the body, this thickened ring curves inward towards the transverse portion (*i*) of the circulating system within the body. The meaning of this will be readily explained in a little older stage, in connection with the development of the peripheric circulatory system.

Soon the spinal tube (Pl. 12, fig. 11, *e*) loses its spatulate shape at the posterior end, by continuing to close over and growing narrower, till its extremity appears to vanish in a long, slender point. At the cephalic extremity, the spinal tube, constituting the brain, has approximated its upward folding edges, (Pl. 12, fig. 8, e^3, 9, e^3, 9a, e^3,) so as to form a closed arch for a short distance along the region of the optic lobes, and thence to the anterior end of the head. Behind this closed portion, the spinal tube is yet quite open and broadly gaping, (fig. 8, 9, 9a, e^2,) as far back as a point above the heart (fig. 9, *h*).

In connection with the brain, a feature appears which has not been noticeable before. On each side of the ventral portion of the head, and beneath the region of the optic lobes, a slight protuberance (Pl 12, fig. 9 and 9a, *k*) stands out, and is rendered otherwise more conspicuous by the fact that its component elements are differentiated from the mass of cells about them, so as to appear like a clear, broad ring (fig. 9, *k*) imbedded in a darker substance. From its position in the head, and its relation to the optic lobes of the brain, there can be no doubt that this is the eye. A similar differentiation occurs on each side of the head, opposite the posterior part of the gap of the brain, which is still open. Here the clear ring, (Pl. 12, fig. 8, 9, and 9a, *l*,) when viewed from above, appears to be a cup-shaped depression, (fig. 9a, *l*,) from the bottom of which a broad band of similar substance runs toward the base of the brain. This is unmistakably the ear. The dorsal vertebræ (Pl. 12, fig. 9 and 9a, *f*) are visible, close to the ears, and extend along each side of the whole length of the spinal tube to its end (Pl. 12, fig. 11, *f*). The chorda dorsalis, now much elongated, underlies the spinal marrow, from the base of the optic lobes (Pl. 12, fig. 9a, *g*) to nearly the extreme end of the body (Pl. 12, fig. 11, *g*). Behind the vanishing part of the spinal tube (Pl. 12, fig. 11, *e*) the body is constricted considerably, and then expands into a short, oval termination, which contains the parts of the spinal, vertebral, and musculo-cutaneous layers that are not yet isolated. The sides of the body (*p*) are folded inwardly and downwards, and the anterior and posterior edges of the ventral cavity (Pl. 12, fig. 5, *o*) are still farther approximated than before, so that, when the body is laid upon its back, it resembles a canoe partly decked over, with an elevated prow.

On each side of the head, opposite the open part of the brain, three or four transverse furrows are visible (Pl. 12, fig. 8, *m*, 9, *m*). These extend from near the lower median line of the head upward, almost to a level with the edges of the still unclosed spinal tube, (fig. 8 and 9, e^2,) and appear to be superficial incisions in the musculo-cutaneous layer. These are the branchial fissures. The heart (Pl. 12, fig. 9, *h*) has bent upon itself slightly, assuming a sigmoid flexure, so as to produce a protuberance in this part of the body. The large vessel, spoken of above, in a little younger stage, as a broad, transverse band (see p. 547; Pl. 12, fig. 7, *i*) which is connected with the posterior portion of the heart, is now bent sharply upon itself, so as to assume a furcate shape (Pl. 12, fig. 10, *i*). The heart (*h*) has but a slight flexure laterally, but is bent strongly upon itself as it follows the curvature of the body to join the forked vessels (*j*) which run towards the head. The clear, dark, circular area, which we have already mentioned above (Pl. 12, fig. 7, *d*) as surrounding the embryo, still preserves a homogeneous aspect, (Pl. 14, fig. 12,) but has expanded considerably, so as to exceed the embryo by one half the length of the latter.

Proceeding to a still further advanced phase, we find the embryo strongly bent upon itself vertically at each end, (Pl. 12, fig. 10,) so as to bring the head down towards the heart, and the tail towards the abdominal cavity. The tube of the spinal marrow is nearly altogether closed over (Pl. 12, fig. 10, e^3, e^4, 10a, *e*, 10b; *c*, 10c, *e*). The apparent gaping in one of the figures (fig. 10a, *e*) is owing to the circumstance that the view is not taken from the outer surface, but from the deeper parts of the spinal tube, thus showing the hollow passage through and along the organ. The dorsal vertebræ (Pl. 12, fig. 10, *f*, 10a, *f*) are more clearly defined. The eyes and ears are not so prominent as in the last-mentioned phase. The subsidiary layer, following the curvatures and the approximating sides of the lower surface of the body, has become a sac, whose broad mouth opens downwards through the abdominal aperture (*o*) and in contact with it. Thence it spreads out, as heretofore, over the parietes of the yolk mass. The heart, (Pl. 12, fig, 10, *h*,) in this animal, appeared still as it has already been described before; but, in continuance of this part of the subject, we may now point out the peripheric extension of the circulatory system. The clear, dark space bounded by an annular thickening of the subsidiary layer, (Pl. 12, fig. 7, i^1,) which has already been described, (p. 547,) is more or less streaked here (Pl. 13, fig. 10; Pl. 14, fig. 11) by dark, transparent channels, that run radiatingly from the embryo towards the parietes of this transparent area, where a few of them join a broken, irregular circle (fig. 11) of similar channels. The ring bending towards the body, which was pointed out in a former stage (Pl. 12. fig. 7, i^1) as curving in close connection with the transverse broad band, or vessel, (*i*.) behind the heart, corresponds here to the circular channels, which also curve inwards towards the same region as above, and join the transverse, or rather now forked, vessel, (Pl. 12. fig. 10, *i*,) which enters the posterior end of the heart (*h*). Within all these channels, so far as they are directly in connection with the heart, there is a backward and forward motion of a granular, albuminous fluid, which is totally different in appearance from the blood, containing blood corpuscles, which is usually described as indicative of the earliest circulation.[1] This fluid is set in motion by the impulsive contractions of the heart; as may very easily be seen by the help of a low magnifying power. This clear, dark area, which we now know to be the vascular area, is considerably increased in size beyond the space it occupied when first noticed, (see Pl. 14, fig. 12,) so as to have a diameter of about double the length of the embryo, and equal to one sixth of the circumference of the egg.

At the next step, we find the embryo still more bent upon itself, especially at the anterior part, (Pl. 12, fig. 6,) where the head curves downwards and backwards so as to approximate the cardiac region (*h*). A greater definiteness obtains in the outlines of the eyes (Pl. 12, fig. 6, *k*; Pl. 21, fig. 28) and ears (Pl. 12, fig. 6, *l*; Pl. 21, fig. 27). The spinal tube is still more closed over (Pl. 12, fig. 13, *e*). The dorsal vertebræ are more marked posteriorly (fig. 12, and 13, *f*). The subsidiary layer is still further contracted at its mouth, by the increased constriction of the abdominal parietes (fig. 13, *o*). The heart, (Pl. 12, fig. 6, *h*,) in addition to the sigmoid flexure of the last phase, has become swollen and curved downward towards the ventral surface of the body, carrying with it the superposed musculo-cutaneous layer.[2] At this advanced stage of growth, the embryo is so transparent that the whole internal organization may very easily be recognized without the help of dissection. This transparency, however, does not amount to that glassy clearness which it obtains among the embryos of Fishes. The further progress in the evolution of the nervous system, the dorsal vertebræ, the chorda dorsalis, the eyes, the ears, and the branchial fissures, will be described when treating of the special development of each of these organs; it being sufficient here to have traced their origin and mode of growth up to that period when the nature of each and all of them could be easily recognized. Hereafter we shall merely mention the degree of development of these organs at each phase, without adding any special details respecting the process through which they have passed to arrive at any particular stage, and at the same time describe

[1] This early circulation of an albuminous fluid with minute granules probably precedes the formation of the blood in all Vertebrates. I have observed it in Fishes and Birds.

[2] If the embryo is cut out of the egg in connection with the vascular area and immersed in sugar syrup, it will live, and its heart beat vigorously, for at least twelve hours. In some instances, when the whole egg was sunk in syrup, after the shell had been taken off, the embryo lived not less than thirty-six hours. We have several embryos of different ages which have been preserved in strong syrup for more than two years, and the blood has just as clear and brilliant a red color as when it flowed through the vessels of the living animal. Caution, however, is necessary in transferring the embryo to the densest syrup in which it is eventually to be preserved, else the animal may shrink and become distorted.

the mode of origin of whatever other organs may make their appearance in these later stages of embryonic growth.

In a slightly farther advanced stage, (Pl. 18a, fig. 13,) we find the amnios (a^1) has nearly closed over; the nervous system is about the same as in the last; the eyes (k) have each a distinct crystalline lens (Pl. 24, fig. 8, k^3); the ears are more trumpet-shaped, (Pl. 18a, fig. 13, l,) and extend deeper into the head; and the dorsal vertebræ are perhaps more separated from each other. In this embryo we have been enabled to trace very distinctly the connection of the forked vessel, (i,) which opens into the heart, (h,) with the converging vessels mentioned above, (see Pl. 12, fig. 7, i^1–i; Pl. 14, fig. 11,) which come from the outer edge of the area vasculosa. From the anterior part of the heart, the ventricle, (Pl. 18a, fig. 13, h^4,) a large vessel (h^1)[1] arises and passes along just below the branchial fissures (m, m) towards the head. From the dorsal side of this large vessel, the aorta, (Pl. 18a, fig. 11, h^1,)[2] other small vessels (h^2, h^2, h^2) proceed between the branchial fissures (m) on each side of the head upwards, and join another large vessel, the dorsal artery (j^2). The dorsal artery follows closely against the median line of the vertebral layer above, till it reaches the posterior end of the body. [See a little older embryo, (Pl. 18a, fig. 14, j^2,) to trace its course as seen in profile.] When the embryo is viewed from below, (Pl. 18, fig. 7,) the dorsal artery may be seen giving off to the right and to the left in the abdominal region, numerous vessels, which at once spread and ramify through the vascular area (p. 538). These numerous and minute vessels, the omphalo-meseraic arteries, have a general trend towards the circular channel spoken of above, (p. 549,) the so-called vena terminalis, into which they empty. On each side of the head the vena terminalis converges and joins the forked vessel, (Pl. 18a, fig. 13, i, i,) which is connected with the posterior end, the auricle, of the heart. Thus we have a perfect circuit in the circulation of the blood. At the outset, the heart, the first part of the vascular system in which a fluid may be seen in motion, sends the blood forward, through the arteries of the branchial fissures, to the dorsal artery; the dorsal artery sends off currents into the area vasculosa; these currents, the omphalo-meseraic arteries, empty into the vena terminalis; and the vena terminalis returns the blood to the heart, through the forked vessel, the vena afferens.

There are also, within the body, circuits of blood of lesser extent than that

[1] Pl. 18a, fig. 13, h^4, h^1. The dotted line, extending in the original drawing from these letters to the parts they designate, has been accidentally omitted here. From h^4 the dotted line should extend to the dark hole, in the nearest part of the heart, to that part of the aorta which is just below the longest branchial fissure, (m,) which runs from the ear (l) downwards.

[2] This figure, although representing a little older phase, will serve to show the direction of the vessels in this region of the body.

already described. The dorsal artery, which runs along the middle line of the body, (Pl. 18, fig. 7,) forks as it reaches its posterior termination. Each limb of the fork doubles outwardly upon itself in a horizontal plane, and then passes forward parallel to, and in the same layer with, the dorsal artery, forming thus an abdominal vein, till it reaches the vena afferens, into which it empties, at a point a little posterior to the heart. That part of the dorsal artery which runs forward and forms a cephalic artery (Pl. 18a, fig. 11, *j*) branches and anastomoses extensively with return currents, the cephalic veins. These veins empty into the vena afferens, near the point where the abdominal veins discharge their contents into the heart. At the middle third of the body, the substance of the subsidiary layer is very much thickened around and above each abdominal vein, the thickening being shaped into a semicylindrical band, with the convex side downwards. Each thick band lies principally between the abdominal vein and the dorsal artery, and is peculiar from its having dark, obliquely transverse striæ along its whole length.[1] The relations of these two bands, one on each side, to the dorsal artery and the abdominal veins, and the peculiar transverse zigzag striæ within their thickness, correspond so closely in their relations and appearance to the organs, which, in a more advanced embryo, may be recognized as the Wolffian bodies, that we have no hesitation in identifying the former with the latter, both in name and in function. The sides of the abdominal cavity are more constricted than we have known to obtain before. The branchial fissures (Pl. 18a, fig. 13, *m*) extend through the musculo-cutaneous layer, and open into the cavity of the pharynx. The subsidiary layer, by folding together along the axis of the body and bringing the faces of its two opposite halves in contact, forms a double pendent curtain, the height of which equals the thickness of the body above it. The double lower edge of this curtain still remains in connection with the rest of the subsidiary layer, the latter expanding horizontally as heretofore, but at a lower level. In a transverse section (Pl. 9c, 7) of the posterior third of the body, we do not find the least trace of a curtain; but, on the contrary, the subsidiary layer (n, o^1) expands directly outwards from its basis of attachment. This layer, excepting that the dorsal artery, the abdominal veins, the Wolffian bodies, and the pendent curtain have been formed by it, appears to have undergone no other change than to adopt the shape which the approaching sides of the body have impressed upon it.

Another embryo of the same species, Nanemys guttata, (Pl. 18a, fig. 14,) although one day younger than the one just described, is more advanced.[2] The whole body

[1] See an older phase for the peculiar appearance of this band (Pl. 18a, fig. 8, 9).

[2] The amnios in this figure is represented as torn open along the middle region of the body.

is more developed. The brain (c^3)[1] is already slightly three-lobed; the region of the medulla oblongata (e^1) is more closed over; the eye (k) is more isolated from the surrounding parts: the heart is much more enlarged, and stands out conspicuously beyond the ventral surface of the body; the aortic bulb (h^1) is now quite a prominent feature. At a point (j^3) a short distance behind the heart, the dorsal artery (j^2) gives off only a single, but very broad, omphalo-mesmeraic vessel, (j^4,) as if the many vessels of the last phase had merged into one great channel. As this figure, with the exception of the head, is not an exact profile, but rather a combination of a profile view and a view obliquely from above, the dorsal artery (j^2) appears to be nearer to the ventral surface than it really is, and the dorsal vertebræ (f) seem thicker than is natural.

In a little more advanced phase, (Pl. 13, fig. 2, and 3,) the spinal marrow is more extended backwards into a distinctly developed tail (wood-cut 1).[2] The dorsal vertebræ (wood-cut 1, f) reach to the root of the tail. The eyes have become entirely inclosed within complete orbits. The heart has become three-chambered; the single auricle of the last phase (Pl. 18a, fig. 14, h) being now divided into two cavities, thus leaving its fish-like character, and adopting a structure which is peculiar to scaly Reptiles alone. The dorsal artery (wood-cut 1, j^2) extends to the end of the tail, and the cephalic artery branches extensively in the head. The fork of the vena afferens, which in the beginning originated close to the heart, (Pl. 12, fig. 7, i, i, fig. 10, i,) but later receded (Pl. 18a, fig. 13, i, i) from this organ, is now (Pl. 13, fig. 2) some distance beyond the body, towards the vena terminalis. This embryo presents a feature (wood-cut 1, n^0) in the posterior region, which, at first sight, might be mistaken for the hind foot just budding forth. Upon close scrutiny, however, we discover that this protuberance is in the perpendicular plane of the axis of the body, and is based upon that area close to where the tail arises. This protuberance is a simple hollow sac, formed by the folding together of the two opposite halves of the subsidiary layer, uniting their edges below. The dorsal artery (wood-cut 1, j^2) runs close upon and above this protuberance, thus showing that the latter is a later production of the same layer which developed the former, the dorsal artery, upon its middle line. Since we find this protuberance (wood-cut 1, n^0) in such a connection, and moreover see traces of bloodvessels coming from the dorsal artery (wood-cut 1, j^2) branching in it, we conclude that this must be the allantois.

Wood-cut 1.

[1] In Pl. 18a, fig. 14, the first letter to the left of k, should be c^3, instead of e^1.

[2] This wood-cut corresponds exactly to the parts in Pl. 13, fig. 2 which it represents, and is chiefly intended to point them out more minutely, no letters having been introduced in the original figure.

There are two vessels to be seen here, one on each side of the body, which run, from the region of the allantois, forward (wood-cut 1, i^2) — as the arrows indicate (Pl. 13, fig. 2) — along the sides of the body, and empty into the heart. That these are the allantoidian veins there can be no doubt, since no other vessels are developed in this region at any time. Between the point of origin of the allantois, on the one hand, and the anterior edge of the abdominal opening, on the other, the subsidiary layer remains in open communication with the mass of yolk below.

As this layer proceeds beyond the edge of the abdominal cavity, it rises gradually, until, at the edge of the area pellucida, it comes to a level with the back of the animal, and with it presses closely against the shell membrane. At the same time it bears along, within its thickness, the vessels of the vascular area, so far as the vascular network extends. The vessels of the vascular area have become very distinct, and run more parallel to each other than heretofore. Those which arise distinctly from the dorsal artery have considerably decreased in number, but are enlarged, as regards the size and capacity of each; moreover, they have a general tendency towards one point (Pl. 13, fig. 3, *q*) of the body. The head and fore part of the body are sunk so much towards the centre of the yolk, that the subsidiary layer forms a very deep hood, (Pl. 13, fig. 2,) as it folds upwards around the cephalic region, and rises to a level with the other portion of the layer. About this time the body turns upon its axis, (Pl. 13, fig. 2, and 8,) so as to present its left side towards the centre of the yolk. This change in the position of the embryo has been noticed in a former paragraph, (p. 541,) where it was shown that it is owing to the closing over of the amnios, by which process that portion of the amnios which embraces the body is separated from the peripheric portion of the germino-amniotic layer, and the latter part ceases to support the body in a vertical position.

In the next more developed phase which we have investigated, the embryo is so much bent upon itself as to form a semicircle; but the head and thorax are more suddenly curved than the posterior region of the body. The end of the head is more elongated and pointed. The brain (Pl. 24, fig. 7, c^2, c^5,) is divided into at least three lobes or compartments, by two deep folds trending in the direction of the axis of the body, the deeper one of which (c^5) is behind the eye, (k,) and the other before it. The eyes (fig. 7, k, and fig. 7a, k) are increased in size. The ears (Pl. 24, fig. 7, l) are very broad, trumpet-shaped. The dorsal vertebræ have extended very far into the tail (Pl. 24, fig. 14, f, fig. 15, f); but they are very diminutive there, in comparison with those in the more anterior region of the cerebro-spinal axis, and the vertebral layer (fig. 14, f^1) extends to the tip of the much elongated tail. The heart (Pl. 18a, fig. 11, h^3, h^4, fig. 12,

h^3, h^4; Pl. 24, fig. 7, h^3, h^4) is not sensibly changed; but the dorsal artery (Pl. 18a, fig. 11, j^2) has increased in diameter, especially in a horizontal direction. Just behind the heart and close to the ventral surface there is a small, dark, round body, which, in all probability, is the incipient liver. The allantois (Pl. 24, fig. 15, n^6) has considerably increased in size, and is transformed into a two-lobed organ, by a longitudinal constriction. From the region of the heart to the basis of the allantois, the subsidiary layer (Pl. 24, fig. 14, *n*, fig. 15, *n*) remains broadly open, but not to the extent that obtained in the last phase. The aperture of this layer is limited by the contracted sides of the body, which have reduced the abdominal opening (Pl. 24, fig. 14, *o*) to one quarter the length of the body. The branchial fissures (Pl. 18a, fig. 11, *m*; Pl. 24, fig. 7, *m*) are more or less gaping. On the exterior of the body, at a short distance behind the heart, and also just posterior to the allantois, the musculo-cutaneous layer projects in the form of little bud-like excrescences (Pl. 24, fig. 14, w^1). There are a pair of these in front and a pair behind, corresponding to the position of the feet.

Progressing still farther, we find an embryo with the head still more bent upon the thorax (Pl. 14, fig. 5) than in the last, so as almost to touch the heart: this embryo exhibits also a considerable increase of size. The brain (Pl. 24, fig. 9a, c^2, c^3, c^5) is more deeply folded, especially at the sides (c^5). The eyes (fig. 9a, *k*, fig. 12, *k*) are perfectly round, and very prominent; the pigment layer is quite black. The front end of the head is indented, close to the lateral parietes on each side of the middle line, by a deep, broad depression, (Pl. 24, fig. 12, *v*,) the lower side of which is bounded by a diverticulum-like protrusion from the inferior surface of this region. The dorsal vertebræ are more numerously developed in the tail (Pl. 14, fig. 5). The heart (Pl. 24, fig. 9, h^3, h^4, fig. 9a, h^4) is much enlarged, and projects so far on the abdominal side, that it renders this region the thickest part of the body; its auricles (fig. 9, h^3) are very distinct from the ventricle, (h^4,) not only by their position, but also by the peculiar spongy nature of the cavity of the ventricle (fig. 9, h^4, fig. 9a, h^4). The network of peripheric blood-vessels in the head is more numerously developed, especially at its end (Pl. 24, fig. 9a). The fork of the vena afferens (Pl. 14, fig. 5) is now at the vena terminalis; the venæ abdominales (Pl. 24, fig. 9, i^3) and the venæ capitis (i^5) empty with larger channels into the heart (h^3). The abdominal veins (fig. 9a, i^3) are closely approximated to, but run in a plane a little below, the dorsal artery (j^2). The omphalo-meseraic arteries (Pl. 14, fig. 5) spring from one common point of departure, and, by their increased size, render the vascular area much darker. The subsidiary layer has undergone a considerable change at the anterior part of the body, both in front and above the heart, where, in the form of a great, capacious tube, (Pl. 24, fig. 1, *l′*, *l″*, *l‴*,) it forms the lining of the cavity into which the branchial fissures open; its right and left sides are so folded inwardly and longitudinally as to shape the whole into a double channel, one of which (*1′*, *1″*) lies next to the back, and the other, which is much narrower, (*1‴*,) next to the ventral side of the body. These channels communicate with each other by means of a small aperture, (*5*,) which is situated near the posterior end of the longitudinal fold. From the posterior end of the lower channel, (*1‴*,) two short blind sacs, (*1*, *1*,) one on each side, protrude horizontally and in a backward direction, pressing against that portion of the subsidiary layer (*1′*) which remains a single tube.

The larger of these channels occupies by far the greater part of the cavity in front of the heart; but, behind this organ, it grows narrow, giving place to a larger, globular, dark body, (Pl. 24, fig. 9, *r*, 9a, *r*,) which occupies nearly the whole breadth of the body next to its ventral side, and close behind the heart; and finally, at the abdominal opening, it flares broadly open, but not so widely as in the last phase, forming a direct communication with the yolk mass below. This is the beginning of the intestinal canal, the broadest part of which corresponds to the œsophagus, and the part that follows behind, to the stomach; the long, thin intestine of the adult being at this age a broad, open layer, excepting at the extreme posterior end, where the allantois springs from it.

The smaller of these channels commences in front, close to the angle where the head is bent upon the neck, (Pl. 14, fig. 5,) and extends backwards as far as the heart, and there, as we have already mentioned, divides into two blind sacs. Every relation which this channel bears to the œsophagus points out its identity with the respiratory system, and therefore the single part of the channel must be the windpipe, and the two blind sacs, the lungs. We have not traced the origin of the large, dark body (Pl. 24, fig. 9, *r*, 9a, *r*) behind the heart; but from its size, position, relation, and dark color, it must be the liver. It will be noticed that the subsidiary layer, which composes these two channels, is separated into two strata. The interior of these strata, both in the intestine (Pl. 24, fig. 1, *2′*, *2″*) and in the lungs and windpipe, (*2*, *2‴*,) is no doubt the epithelial layer. The allantois (Pl. 14, fig. 5) is not larger than in the last-mentioned phase, but it shows traces of bloodvessels. The Wolffian bodies, blending closely with the venæ abdominalis, (Pl. 24, fig. 9a, *r*³,) render the latter apparently larger than they really are. The abdominal opening is now contracted to a much diminished space, lying between the liver (Pl. 24, fig. 9a, *r*) in front, and the allantois behind, and narrowed to half the width of the body. The feet (Pl. 24, fig. 9a, *w*) are not further developed than before. The caudal portion of the body, the tail, (Pl. 14, fig. 5,) beyond the allantois, is much longer and more slender than in the last stage; and at its base, close behind the allantois, where the anus originates at a later period, there is a deep, transverse fissure, the first indication of the posterior opening of the alimentary canal.

Another embryo, (Pl. 14, fig. 4,) to all appearances identical in development with this, has a considerably larger and much more highly vascular allantois. The allantoidian artery (*o*) is quite large, and the allantoidian vein (*t*) has already assumed that wavy course which is so characteristic in older phases. The abdominal artery and the abdominal vein are here very conspicuous along the whole length of the body, even to the end of the tail.

The embryo of another species, Nanemys guttata, (Pl. 16, fig. 6, 6a,) although not more developed than the last two, has an allantois still larger than either of them. It extends its bulk along the whole abdominal region, from the heart to the tip of the tail, and even beyond. The median constriction, which we have already pointed out in a much younger phase, (p. 555; Pl. 24, fig. 15, n^0,) is here very conspicuous, yet does not trend in the direction of the longitudinal axis of the body, as at the time of its earliest appearance, but is twisted so as to run obliquely across its former path. This change corresponds with the alteration in the position of the allantois, which, instead of lying symmetrically across the embryo, rests with one part of its constricted bulk next to the head, and the other part in the caudal region. This is the first indication we have of the tendency of this organ to spread over the surface of the animal. After noticing that the line of constriction of the allantois is occupied by the main vessels, arteries and veins, and referring to the youngest phase in which this constriction is visible, but without bloodvessels, it becomes evident that the path of the allantoidian arteries and veins is marked out almost from the time of the origin of the allantois.

We have already pointed out the change in the attitude of the embryo (p. 541, and 554; Pl. 13, fig. 2) from a vertical to a horizontal position, with its left side downwards; but will refer to it again now, in connection with a corresponding change which the allantois has assumed in its position. Inasmuch as the right half of the allantois cannot expand laterally, with reference to the embryo, on account of the egg shell, which is closely above, it must take another direction, and consequently the left half also is moved from its former position. It is this change in the direction of its expansion that has twisted the whole allantois upon its axis. Here, too, the sinking of the area pellucida becomes conspicuous, not only in consequence of its having fallen below the general level of the vascular area, but also because of its bearing upon the expansion of the allantois, to which it gives place. The boundaries of this depression are marked by a sudden bending upwards of the omphalo-meseraic bloodvessels. The bloodvessels of the allantois are very numerous, and anastomoze with each other by a multitude of capillaries, evidently evincing a high state of vascular organization and activity. As regards the other parts of the embryo, we have but little to notice that is new, except to point out the already minute ramifications of bloodvessels in the head, a feature not represented in the two embryos last mentioned. At this stage, the so-called vena terminalis also merits particular notice, inasmuch as it has now become as distinctly a vessel as it ever will be. In Turtles' embryos this vein never becomes a single perfect circular channel, as is the case among Birds. Wherever there appears to be a single large current, it will be found, upon close examination, to be made up of an infinite number of minute anastomozing vessels. (See Pl. 17, fig. 6, which, although a little older, exhibits the same appearance.) It will soon be seen that this peculiarity becomes a more prominent and readily noticeable feature in further advanced stages.

At this age, the diameter of the vascular area of this species, and of all the other species with oval eggs, is broader in one direction than in the other, its greater breadth corresponding to the longer axis of the egg. In globular eggs there are no such differences; but the vascular area always continues more or less circular. In their younger stages of development, oval eggs also have a circular vascular area, as is shown in the case of Nanemys guttata (Pl. 18, fig. 7). We have mentioned previously the growing tendency of the vessels of the vascular area to trend in a direct line from the point of their origin towards the vena terminalis. This tendency is now carried out to the utmost in this egg, so as to give to the vessels a stiff and rigid appearance (Pl. 16, fig. 6).

The next older stage (Pl. 14, fig. 2, 2a; Pl. 18, fig. 8; Pl. 18a, fig. 6–10; Pl. 24, fig. 2, 2a; Pl. 9e, fig. 8, 8a, 9, 9a; Pl. 19, fig. 4; Pl. 22, fig. 9) offers some new and remarkable features in addition to a further development of the different organs.

The brain of this embryo (Pl. 14, fig. 2a; Pl. 18a, fig. 9; Pl. 22, fig. 9, *b*, *b*¹) has become strongly lobed, especially in the region above the eyes, where it is so prominent as to give the head a crested appearance. The lower side also projects downwards between the eyes, (Pl. 22, fig. 9, *c*,) where it constitutes the optic lobe. The dorsal vertebræ reach to the tip of the tail (Pl. 14, fig. 2a). They have so approximated their opposite halves (Pl. 9e, fig. 8, *f*, fig. 8a, *f*) as almost to inclose the spinal marrow (fig. 8, *e*, fig. 8a, *e*) in a perfect tube. The chorda dorsalis (fig. 8, *g*, 8a, *g*, 9, *g*, 9a, *g*) is still very conspicuous, and appears to have increased in diameter. The musculo-cutaneous layer (Pl. 9e, fig. 8, *p*. *p*¹, fig. 8a, *p*, *p*¹) is separated into two portions, namely, an outer (fig. 8, 8a, *p*) or dermal layer, and an inner (fig. 8, 8a, *p*¹) or musculo-costal layer. The end of the head below the eyes is quite pointed (Pl. 14, fig. 2a). The eyes are very prominent (Pl. 14, fig. 3; Pl. 18a, fig. 7, *k*, and fig. 9; Pl. 22, fig. 9, *c*). The retina (Pl.

22, fig. 9, *d*, *d*[1]) is folded inwardly at several points, a peculiarity which reminds one of the falcate process in the eye of certain Birds, and the flabellum in Fishes. The two deep depressions at the end of the head, noticed in a former page, (p. 555, Pl. 24, fig. 12, *v*,) are here (Pl. 18a, fig. 9, *v*) very much broadened, but at the same time the edges are curved inwardly towards each other.

The heart (Pl. 18a, fig. 8, and 9, h^3, h^4) is separated into two very distinct portions, the auricle (Pl. 18a, fig. 6, h^3) and the ventricle, (h^4,) which are joined by a narrow tubular isthmus. Although the heart is divided into three chambers, the course of the blood is not at all diverted from the channel in which it ran at the beginning. In one of our figures, the heart (Pl. 18a, fig. 10, h^3, h^4) is so displayed that its threefold division may be readily seen, and the course of the blood easily understood. From the receiving chamber, the right auricle, (h^3,) the blood passes directly into the left auricle, (the middle chamber in the figure,) and from that into the ventricle, (h^4,) and thence, through the bulbus arteriosus, (h^1, fig. 6, h^1,) into the dorsal artery, etc. The vessels which ramify around the brain are becoming very numerous, (Pl. 14, fig. 2a; Pl. 18a, fig. 7, i^5,) especially (Pl. 18a, fig. 7, *j*) in the neighborhood of the medulla oblongata. The dorsal artery (Pl. 9e, fig. 8, j^2, fig. 8a, j^2; Pl. 18a, fig. 7, j^2, fig. 7a, j^2, fig. 8, j^2) runs to the tip of the much elongated tail. The omphalo-meseraic artery (Pl. 18a, fig. 8, j^4, fig. 9, j^4) is much elongated, and projects as a single vessel, far beyond the lower surface of the body, to where the intestine (n^1, n') communicates with the yolk, and then ramifies, as usual, in the vascular area. The abdominal veins (Pl. 18a, fig. 7, i^3, fig. 7a, i^3, fig. 8, i^3) appear to be in very intimate connection with the Wolffian bodies (fig. 7, *q*, 7a, *q*, 8, *q*). The allantoidian artery (Pl. 18a, fig. 7a, j^3, fig. 8, j^3, fig. 9, j^3) remains single, from its point of origin (Pl. 18a, fig. 8, j^3) to far beyond the body. The allantoidian veins (Pl. 18a, fig. 7, i^2, fig. 7a, i^2, fig. 8, i^2, fig. 10, i^2) are remarkably wavy in their course along the sides of the body, and even to the point where they empty (Pl. 18a, fig. 7, i^4, fig. 8, i^4, fig. 10, i^4) into the venous sinus. The omphalo-meseraic or afferent vein (Pl. 18a, fig. 8, *i*, fig. 9, *i*, fig. 10, *i*) empties, with the abdominal, the cephalic, and the allantoidian veins, into a common reservoir, the venous sinus (fig. 8, i^4, 10, i^4). Its course near to and within the body is in contact with and along the lower surface of the intestine, (Pl. 18a, fig. 8, n', fig. 9, n',) and upon the upper surface of the liver (fig. 8, *r*, and 9, *r*).

The intestine (Pl. 9e, fig. 8, n^2; Pl. 18a, fig. 7a, n^1, fig. 8, n', n^1, n^4, fig. 9, n', n^1, n^2; Pl. 24, fig. 2, n^2, n^4) has become longer than the whole abdominal region, and projects in a fold through the ventral opening. It still remains in open communication with the yolk, but, with a narrow aperture at its posterior end, (Pl. 18a, fig. 8, n^6,) projects slightly beyond the body, but does not open so as to form an anus. The mesenterium, (Pl. 9e, fig. 8, n^8, fig. 8, n^8,) that part of the intestino-subsidiary layer which keeps the intestine suspended from the median line of the body, may now be recognized as the pendent curtain which was formed by the subsidiary layer in a much younger embryo (see p. 552). That part of the intestine which passes along above and around the liver (Pl. 9e, fig. 8, r; Pl. 18a, fig. 9, r) has become considerably swollen, (Pl. 9e, fig. 8, n^2; Pl. 18a, fig. 9, n^2,) so as almost to equal the proportions of the full-grown stomach. The respiratory apparatus (Pl. 24, fig. 2, t, t', fig. 2a) has separated entirely from the intestine, (fig. 2, n^2, n^4,) and the lungs have become swollen (fig. 2, t', fig. 2a). The liver (Pl. 9e, fig. 8, r; Pl. 18a, fig. 8, r, fig. 9, r) is very dark, and has lost the globular form of earlier periods, (p. 556, Pl. 24, fig. 9a, r,) and become more flattened vertically, and lobed on the left side, where it overlaps the stomach (Pl. 18a, fig. 9, n^2).

The Wolffian bodies (Pl. 9e, fig. 8, q, fig. 8a, q^1; Pl. 18a, fig. 7, q, fig. 7a, q, fig. 8, q, fig. 9, q) occupy fully one half the length of the body, and exhibit very clearly the zigzag striæ spoken of in a former page (p. 557). In a transverse section of the embryo (Pl. 9e, fig. 8) just behind the fore feet, the duct (q^1) of the Wolffian body (q) is shown to be a dorsal channel, and already of a considerable diameter.

The allantois (Pl. 14, fig. 2, 2a, 3; Pl. 18, fig. 8; Pl. 18a, fig. 7a, n^3, j^3, fig. 8, j^3, fig. 9, i^2, j^3) reaches from the head to far beyond the tail, and laps over upon the right side of the body, so as to cover a large part of the posterior region of the body (Pl. 14, fig. 2a). In the case of another embryo, (Pl. 14, fig. 2,) of the same degree of development in other respects, the allantois overlaps all but the head and shoulders, and extends so far beyond as to cover four fifths of the area pellucida. The bloodvessels of this organ are very large and thick, and anastomoze with each other by innumerable capillaries. It is a remarkable peculiarity of the allantois that its arteries (Pl. 18a, fig. 8, j^3, fig. 9, j^3) and veins (Pl. 18a, fig. 8, i^2, fig. 9, i^2) run parallel and close to one another for a long distance, in that part of the organ which is outside of the body. In a view from below, (Pl. 18a, fig. 7a, and 9,) it is shown how the allantoidian arteries (j^3) arise, one from each side of the dorsal artery, (j^2,) and, bending around the intestine, (n^1,) converge just below it, and thence run along the narrow peduncle of the allantois out into its great expanded mass.

The abdominal opening is contracted so as to equal about one sixth of the length of the body, exclusive of the tail.

The feet project considerably beyond the body, and have an oval, paddle shape; but, as yet, there are no signs of toes. This is the earliest period in which bloodvessels have been seen in the feet (Pl. 14, fig. 2a).

The area pellucida, (Pl. 14, fig. 2, 2a; Pl. 18, fig. 8,) and the space to a considerable extent beyond it, are much more sunk than in the last stage, (p. 557, Pl. 16, fig. 6,) so as to correspond to the increased size and expansion of the allantois. The area vasculosa covers at least one half of the yolk mass (Pl. 18, fig. 8). The fork of the vena afferens, and the portion of the vena terminalis and of the omphalo-meseraic vessels next to it, (Pl. 14, fig. 2a,) have sunk below the surface of the yolk mass, but yet not so far as to be invisible. In another instance (Pl. 14, fig. 2) the vena afferens (*r*) itself, and at least one half of the vena terminalis, (r^1, r^1) have sunk considerably below the level of the vascular area, and retracted within its former boundary. What appears to be a circular vessel in the place of the one that is now depressed is the line along which the vessels of the area vasculosa bend upon themselves, and plunge into the yolk mass, in order to join the vena terminalis (r^1, r^1).

The yolk sac has decreased considerably in bulk, and occupies about two thirds of the cavity of the shell, the other third being filled by the embryo and its envelopes. The lungs (Pl. 24, fig. 3, 3a) of an embryo four days younger than this are much more developed; their transverse diameter is much greater at the base than at the apex, so that they resemble in figure the adult state; and the cavity of each is subdivided into two compartments, (fig. 3a, *2*, *2*,) namely, the original one, running along its whole length, as in the last stage, (fig. 2a, *2*,) and another, much shorter, which branches from the main channel at the base of the lung, and trends toward the ventral side of the animal. The epithelial layer, (fig. 3a, *2*, *2*,) which lines this double chamber, is much thicker than in the last phase, not only in the lungs, but also in the windpipe, (*2‴*,) especially where the two bronchiæ branch (*5*). The cavity of the lungs is as yet very narrow, resembling a mere slit along their length.

Up to this period the head has exhibited moderate proportions when compared with the trunk of the embryo, so that its size has not attracted any particular attention. In the next stage, (Pl. 15, fig. 13; Pl. 16, fig. 3; Pl. 18a, fig. 4, 5; Pl. 24, fig. 11,) however, there appears a great disparity between the different regions of the body. The head has increased to an enormous size when compared with its former proportions, so that it almost equals the whole trunk; in fact, if an outline of the head and neck be laid over that of the trunk, the two will be found to be nearly equal in size. The breadth of the head, including the eyes, far exceeds that of the body, although the latter has broadened also. (See Pl. 6, fig. 25, which, although belonging to a totally different family from that of fig. 13, Pl. 15, is yet identical as regards the proportions of the body, so far as a small figure may serve for such a comparison.) The encephalon, just above the eyes, is much broader than has been noticed heretofore, (Pl.

6, fig. 25,) so that in fact this is the widest part of the head, excepting the region which includes the eyes.

Along a line just above the legs, both sides of the body project with a rather sharp edge, which is formed by a longitudinal fold in the skin, so that, passing from below upwards, the body suddenly broadens, and forms, above, as it were a roofing for the lower side of the animal. When seen from above, (Pl. 6, fig. 25,) this roofing appears narrow and ovate, with the broader end towards the head. This is the earliest period at which the shield commences to develop. The wavy surface of the back (Pl. 15, fig. 13) indicates the presence of the ribs, each wave corresponding to a single rib. The tail is also enormously developed, and more than equals the length of the trunk in Chelydroidæ and Emydoidæ; but in Chelonioidæ, Thalassochelys at least, (Pl. 6, fig. 24,) it is not more than half so long.

The eyes are much further developed, the pupil being now well formed in consequence of the perfect closing of the ring of the iris. The broad and deep depressions at the end of the head, mentioned in former pages, (p. 555 and 559; Pl. 24, fig. 12, *v*; Pl. 18a, fig. 9, *v*,) have, at this stage, (Pl. 24, fig. 11, *v*,) become very much constricted at the mouth, so as to leave a very small external aperture. Below these depressions there is a large opening (*x*) in the head, which leads into the beginning of the intestinal canal, and therefore must be the mouth. This being established, it is easy to see that the two depressions (*v*) above the mouth are the openings of the nostrils, and that the two fissures which run from the nostrils to the mouth are each the remains of the posterior fold of the depression. The lower jaw has a distinct emargination at the middle.

The region of the heart and liver still remains the deepest part of the body. The anterior part of the intestine, the œsophagus, (Pl. 18a, fig. 5, n^3,) opens with a nearly horizontal and narrow aperture; the stomach (n^2) is still more bent upon itself as it winds around the left side of the liver (*r*); the long intestine (n^1) is more slender, when compared with the stomach and œsophagus, than heretofore, and still remains in open communication with the yolk sac. The respiratory apparatus (fig. 5, *t*, t^1) is more extended; the windpipe (*t*) is slender, and projects beyond the opening of the œsophagus (n^3); the lungs (Pl. 18a, fig. 5, t^1; Pl. 24, fig. 4) are divided into five broad compartments, or bronchioles, one of which (Pl. 24, fig. 4, *7*) trends at right angles to the others, and in a horizontal direction as regards its position in the embryo. The epithelial lining (Pl. 24, fig. 4, *2*) of the lungs is very much thinner than in the last stage, (Pl. 24, fig. 3a, *2*,) but the outer layer (*1*) is as thick as ever. The heart (Pl. 18a, fig. 5, *h*) retains the spongy nature of former phases; the aortic bulb (h^1) is larger. The efferent vessel, the omphalo-meseraic artery, (Pl 18a, fig. 4 and 5, j^4,) springs now from the same point (fig. 4 and 5, j^5) at which the double dorsal artery (fig. 4 and 5, j^2) unites to form a single channel in the abdominal region, between the Wolffian bodies (fig. 4, *q*). The abdominal veins (fig. 4, i^3) are more distinct from the Wolffian bodies (*q*); the zigzag lines on the Wolffian bodies appear to be in direct communication with the abdominal vein, and, moreover, have a strong red tinge, from which we should judge that they are the bloodvessels of the body in which they are situated. The liver (Pl. 18a, fig. 4 and 5, *r*) is hollowed on its upper side, and on its lower and posterior side a dark body (fig. 5, *u*) is imbedded, which, from its position and green color, must be the gall bladder. The Wolffian bodies (fig. 4, *q*) are not quite so long as heretofore. The abdominal parietes are now closed over, with the exception of a small opening for the passage of the neck of the allantois, and the connection of the intestine and the yolk sac.

The allantois not only covers the whole body, but spreads almost as far as the vascular area (Pl. 16, fig. 3). It is most extended on that side which faces the ventral surface of the embryo, and its vessels have attained to a very large size, much exceeding, in this respect, any of those in the vascular area, even the vena afferens (r^1). The allantois of one of the figures (Pl. 15, fig. 13) representing this stage of development is very much shrunk by being withdrawn from its area of expansion and crowded up near the embryo. It will be noticed how highly vascular the whole surface of the embryo is; from the end of the head to the tip of the tail, the animal appears like a great vascular organ performing respiratory functions. This peculiarity remains permanent in some adult Turtles, namely, in the family of Trionychidæ.[1] The vascular area, as far as it extends superficially, covers about one half the yolk sac, and the vena afferens (Pl. 16, fig. 3, r^1) is plunged deeper than ever into the yolk mass. At the exterior edge of the superficial extension of this area, the downward bend of the vessels resembles very much an irregular vena terminalis, but that part of the area is altogether plunged beneath the surface of the yolk.

The paddle-like shape of the legs is no longer recognizable here; but both the anterior and posterior limbs are now divided into a cylindrical and distinctly jointed leg, and a terminal, rounded, and expanded foot, yet without the least sign of toes. This obtains not only among the higher families of Turtles, (Pl. 15, fig. 13,) but even among the lowest, the Chelonioidæ, as the next phase will show more distinctly (Pl. 6, fig. 24). This is rather remarkable as regards the Chelonioidæ, since in them the foot and leg become eventually, by a gradual metamorphosis, (Pl. 6, fig. 24, 22, 21, 20, 18, 13, 15, 14, 16,) apparently fused into one very large elongated paddle. A comparison of the feet of an advanced

[1] Comp. p. 284.

phase of the embryo of Thalassochelys (Pl. 6, fig. 20) with the very broadly webbed feet of any of the Trionychidæ (Pl. 6, fig. 1–6) may easily show that the dense, tough, and stiff paddle of the Chelonioidæ is not a retrograde metamorphosis tending to the embryonic simplicity of younger stages, (Pl. 18a, fig. 9,) but an excessive development of that which forms the soft web in Trionychidæ, and a hardening of its surface by the growth of closely set scales all over its surface.

In the next phase, (Pl. 14, fig. 1; Pl. 15, fig, 11, 12, 12a; Pl. 16, fig. 5; Pl. 17, fig. 4, 4a, 6; Pl. 21, fig. 22–26, 30; Pl. 23, fig. 1, 1a; Pl. 25, fig. 11,) the different regions of the brain (Pl. 23, fig. 1, 1a) are very distinctly marked out, with the exception of the olfactory lobe, (*c*,) which as yet hardly forms a sensible swelling. As a whole, the brain has about the same proportions as obtain among bony Fishes, excepting that it is strongly bent upon itself, and the hemispheres (*a*) are on a much lower level than the corpora quadrigemina (*b*). The crystalline lens of the eye has already its characteristic cells, (Pl. 21, fig. 30,) arranged in lines (*b*) and in concentric layers. The proportions of the body hold about the same relations to each other as in the last stage, excepting that the trunk is a little deeper in the region of the ventral opening. The back is more curved, the highest point of the arch being at the middle of the shield. The border of the shield is much lower, and does not run in a straight course from end to end, but curves downward, (Pl. 14, fig. 1; Pl. 16, fig. 5,) reaching lowest just above the heart, and has a rather sinuous outline. The ribs are more apparent, (Pl. 14, fig. 1,) and terminate in a broad, wavy band at the edge of the shield, each wave being opposite to a rib. The breadth of the shield is greater, and has a broader ovate shape (Pl. 6, fig. 23). The edge of the abdominal aperture projects considerably, and simultaneously broadens, so as to form a trumpet-shaped umbilical passage (Pl. 14, fig. 1; Pl. 15, fig. 12; Pl. 16, fig. 5) for the allantois and neck of the yolk sac. The allantois (Pl. 15, fig. 11) is more extended in the dorsal region of the embryo, and covers more of the yolk sac; it also embraces the whole trunk of the embryo, above and below, (Pl. 15, fig. 12, 12a,) but as yet leaves the head free. The parallelism of the arteries and veins of the allantois, mentioned in a former page, (p. 560; Pl. 18a, fig. 9,) is here (Pl. 15, fig. 11, 12) particularly noticeable, even to the tips of the smaller vessels. A more highly magnified view (Pl. 17, fig. 4, 4a) shows not only that this parallelism ceases among the very minutest vessels, the capillaries, but that the number of the latter is very large within a small space, and that they run in every possible direction. These two latter peculiarities are very different from what obtains in the superficial portion of the vascular area, (Pl. 15, fig. 11, 12, 12a; Pl. 16, fig. 5; Pl. 17, fig. 6,) where the minutest of the bloodvessels run in a more or less parallel direction to each other, and are comparatively far less numerous (Pl. 17, fig. 6). The vascular area covers more than half of the yolk mass, and plunges deeply into its interior (Pl. 15, fig. 11, 12, 12a; Pl. 16, fig. 5). The vena afferens plunges suddenly into the mass of the yolk at a point close to the head (Pl. 15, fig. 12). The vena terminalis has sunk still further below the surface of the yolk, and at the superficial termination of the vascular area the vessels become very numerous and anastomose freely with one another and with those situated more deeply (Pl. 17, fig. 6).

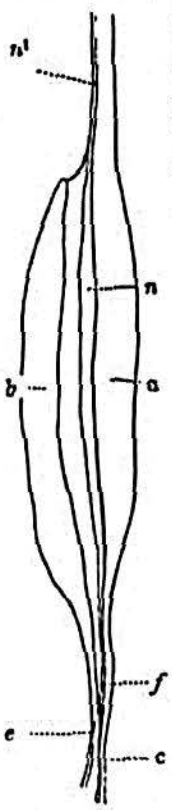
The feet (Pl. 14, fig. 1; Pl. 15, fig. 12; Pl. 16, fig. 5; Pl. 25, fig. 11) begin to show signs of the toes, and the tissue (Pl. 21, fig. 22, 22a, 24) in such places has a different appearance from that of the neighboring parts; but as yet the former passes gradually into the latter (Pl. 21, fig. 25.) The form of the feet is changed, either to a broader fan-shaped figure, as among the Chelydroidæ (Pl. 14, fig. 1; Pl. 15, fig. 12) and Emydoidæ, (Pl. 16, fig. 5; Pl. 25, fig. 11,) or to a more elongated and oar-shaped form, as among the Chelonioidæ (Pl. 6, fig. 22). The anus (Pl. 14, fig. 1) is a very prominent feature at this age, just as it is in the adults of some of the lower families, namely, in the Chelonioidæ and Trionychidæ.

In the next phase, (Pl. 18a, fig. 2, 3; Pl. 17, fig. 2, 3, 3a, 7; Pl. 18, fig. 1; Pl. 19, fig. 13, 13a, 13b, 13c; Pl. 20, fig. 2; Pl. 23, fig. 2, 2a, 2b, 2c, 2d, 2e, 2f, 2g, 2h; Pl. 24, fig. 5; Pl. 25, fig. 4, wood-cut 2,) the former great disproportion between the head and body has lessened very much, the body having grown faster than the head. The embryo has the power to move not only the head and feet and tail, and the lower jaw and tongue, but also the toes, separately, and to roll the eyes. The shield (Pl. 18a, fig. 2 and 3) has become a very prominent feature, and the ribs are quite marked.

The brain (Pl. 23, fig. 2, 2a, 2b, 2c, 2d) has its different regions more distinctly marked out; the olfactory lobes, (fig. 2, 2a, 2b, *c*,) and the cerebellum (fig. 2, 2a, 2b, *e*) in particular, are more prominent, and the olfactory nerve more lengthened (fig. 2, 2a, 2b, from *c*, to c^1). The more elongated hemispheres (fig. 2, 2a, 2b, *a*) are nearly on a level with, and more closely approximated to, the corpora quadrigemina, (fig. 2, 2a, 2b, *b*,) so as to touch them, and cover at least two thirds of the pineal gland (fig. 2a, 2b, *d*). The communications between the different lobes are narrower, both between those of the same side and those of opposite halves. This is especially marked in reference to the opening (fig. 2b, *m*) between the two hemispheres (*a*). The medulla oblongata (Pl. 23, fig. 2, *f*, 2a, *f*, 2b, *f*) is bent forward and downward at an acute angle upon itself, so that the point from whence the acoustic nerve (fig. 2, *l*) arises, touches the lower border of the optic lobe (fig. 2, *k'*). The bloodvessels of the arachnoid plexus, which terminate suddenly, (Pl. 23, fig. 2b, *g*, 2e, 2f, 2g, 2h,) have become quite numerous and elongated. The vascular covering to the fourth ventricle (fig. 2b, *g'*) is highly developed.

The heart (Pl. 18a, fig. 3, *h*) has a much greater transverse than longitudinal diameter, and nearly the same proportions as in the adult. The aorta (Pl. 18a, fig. 3, *h'*) is constricted longitudinally at its base into two channels, the right one of which corresponds to the pulmonary artery of the adult. (See also a little older phase, Pl. 24, fig. 10, *pa*, 10b, *pa*.) The blood corpuscles (Pl. 19, fig. 13, 13a, 13b, 13c) are now quite different from the very transparent globular corpuscles (Pl. 19, fig. 7, a–j) belonging to the younger phase, described p. 558–560, where they should have been alluded to. They are now fully as large as in the adult, but not so flat, nor have they any entoblast. They are remarkably plastic, (fig. 13, 13a, 13b,) but return to their original shape when relieved of pressure, or after stretching (fig. 13b) by being caught against some object passing on the microscope stand. In these respects they resemble very much the yolk cells of the ovarian egg. The bloodvessels in the neck (Pl. 18a, fig. 2) are very numerous, especially in the region of the medulla oblongata (fig. 2, c^5). The omphalo-meseraic arteries (Pl. 17, fig. 7) are remarkably numerous where they run over the surface of the yolk, and have the same stiff appearance spoken of in a younger phase. The omphalo-meseraic veins (Pl. 17, fig. 3 and 7) run in a very irregular course, both horizontally and vertically. The limit of their field of development is a thick stratum of very loosely packed, large, clear, albuminous cells (Pl. 17, fig. 3, 3a).

Wood-cut 2.



At the neck of the vitelline sac the intestine still remains open (Pl. 17, fig. 2); but with a quite small aperture, which does not even equal its own diameter. The anus (Pl. 25, fig. 4, *m'*) is quite a long slit in the lower side of the cloaca. The anal pouches (Pl. 25, fig. 4, *g*, *g'*) are just large enough to be recognized as hollow bodies, opening one on each side of the intestine. The lungs (Pl. 24, fig. 5) are now divided into as many as nine compartments or bronchioles, with a branch of a bloodvessel running to each partition. The liver (Pl. 18a, fig. 3, *r*) is very much flattened, and spread very widely. At its anterior part there is a large hollow, into which the heart (*h*) fits. The Wolffian bodies (Pl. 18a, fig. 3, *q*; Pl. 25, fig. 4, wood-cut 2) are much broader at their middle region. The excretory duct is well marked, (Pl. 25, fig. 4, *c*, *c''*,) from its beginning to its outlet (*c''*) in the cloaca (*l*). On the upper surface of each Wolffian body, next the median line of the body, another similar organ (Pl. 25, fig. 4, *b*) is developing, seemingly by a gradual metamorphosis of the former. That this latter organ is the kidney we are assured, by finding a great abundance of Malpighian bodies (Pl. 20, fig. 2) within its substance. The uriniferous tubes of the kidneys (Pl. 25, fig. 4, *b*) are larger and more convoluted than those of the Wolffian bodies (*a*). Already there are numerous pigment cells upon the surface of the Wolffian bodies (Pl. 18a, fig. 3, *g*). A white and narrow band, of dense substance, tapering at each end, (wood-cut 2, *n*,) runs along the under-side of the Wolffian body, (wood-cut 2, *a*,) and presses closely against its surface. All the relations which this body bears to the surrounding organs mark it as the genital organ, whether of a male or female is not yet determinable, but probably that figured here is a male, if the long, slender, backward prolongation (wood-cut 2, *f*) may be considered a vas deferens. The mouth of the embryo is open as far back as the base of the jaws. The upper jaw, in Chelydroidæ at least, is pointed (Pl. 18a, fig. 3) and slightly hooked. The feet have well marked and movable toes.

In the next phase (Pl. 13, fig. 1; Pl. 15, fig. 4, 5, 5a, 6; Pl. 16, fig. 2, 2a, 2b; Pl. 18, fig. 9, 9a; Pl. 25, fig. 2, 6, 6a, 6b, 8) the proportions of the body are about the same as in the last. The shield is more projecting at its edges, and the large dermal scales are quite conspicuous (Pl. 25, fig. 8). The ventral side of the body shows a new feature: the sternum or breastbone (Pl. 16, fig. 2b; Pl. 25, fig. 8) has made its appearance, and extends longitudinally from the anterior edge of the fore legs to the anus, and laterally, between the anterior and posterior pairs of legs, almost to the edge of the shield. The head is more elongated, especially in front of the eyes, and the upper jaw and nasal region are less curved, being more on a line with that part which lies behind the eyes, so that, on the whole, the head very much resembles that of a bird.

The heart (Pl. 25, fig. 2, *h*) has increased to such a size, that, when filled with blood, it appears very dark and opaque. The vascular area (Pl. 13, fig. 1; Pl. 15, fig. 5; Pl. 16, fig. 2a, 2b) covers four fifths of the yolk mass. The dorsal artery (Pl. 25, fig. 6, *h*, fig. 6a, *h*, fig. 6b, *h*) gives off several vessels (fig. 6, *i*) to the kidneys, (*b*,) and the abdominal veins (fig. 6, and 6a, *d*, fig. 6b, *a'*) distribute numerous venous currents (fig. 2, *a*) to the under-side of the Wolffian bodies. The omphalo-meseraic afferent vessel, (Pl. 16, fig. 2a, r^1, fig. 2b, r^1,) soon after it leaves the body, plunges in a direct line through the yolk mass, and joins the exterior boundaries of the vascular area on the lower side (fig. 2a). Even at this late age there is sometimes an exception to this, when the vena afferens (Pl. 13, fig. 1, r^1) does not sink into the yolk mass till it has reached the periphery of the yolk mass. The allantoidian arteries and veins (Pl. 13, fig. 1, *o*; Pl. 16, fig. 2; Pl. 18, fig. 9) are very conspicuous; their main stems running parallel, side by side. The liver (Pl. 25, fig. 2, *r*) evinces a high degree of vascularity, very large vessels running from its under-side and branching upon its upper surface. The gall bladder (fig. 2, *u*) is larger and darker. The Wolffian bodies (Pl. 25, fig. 2, *a*, fig. 6, *a*, fig. 6a, *a*, fig. 6b, *a*) are considerably shortened and hollowed on their under surface, (fig. 6a, *a*,) and, in combination with the kidneys, (fig. 2, *b*, fig. 6, *b*,) are arched on the upper surface corresponding to the arch of the shield above them. The duct (fig. 2, *c*, fig. 6, *c*, fig. 6a, *c*, *c″*, fig. 6b, *c*) of the Wolffian bodies lies in a furrow between the latter (*a*) and the kidneys, (*b*,) and is very conspicuous from its size, so that it might be mistaken for an oviduct, were it not that it is just as large in the male (fig. 6, *c*, fig. 6a, *c*, fig. 6b, *c*) as in the female. It empties (fig. 6a, *c″*) on the ventral side of the cloaca, (*l*,) and at the base of the allantois (*o*). The kidneys (fig. 2, *b*, fig. 6, *b*, fig. 6a, *b*, fig. 6b, *b*) are considerably increased in size, and have a very distinct outlet (fig. 6, *e*, fig. 6a, *e*) on the dorsal side of the cloaca, (*l*,) and between the bases of the anal pouches (*g*). The uriniferous tubes of the kidneys are very much convoluted, a feature by which they may be very readily distinguished from the Wolffian bodies, in which the uriniferous tubes run parallel from the outer to the inner edge. The genital organs (fig. 6a, *n*, fig. 6b, *n*) are not so slender and tapering as in the last stage, and each has a distinct vas deferens (fig. 6, *f*, fig. 6a, *f*) in the male. The anal pouches (fig. 6, and 6a, *g*) are developed into large, deep sacs, which have nearly the proportions of those of the adult. The cloaca (fig. 6, and 6a, *l*) is very broad and deep, and is flattened on the lower side. The allantois (Pl. 13, fig. 1; Pl. 15, fig. 4, 5, 6; Pl. 16, fig. 2; Pl. 18, fig. 9, 9a) occupies a little more than one half of the egg, and completely envelops the embryo. The umbilical opening is surrounded by a very large and broad trumpet-shaped border (Pl. 16, fig. 2b).

The toes are quite long and prominent, (Pl. 15, fig. 4; Pl. 16, fig. 2b; Pl. 18, fig. 9, 9a; Pl. 25, fig. 8,) and separate in all those Turtles which are not webfooted when adult.

The yolk sac does not always contain a uniformly yellow mass, but more or less of its superior portion is of a semi-albuminous nature (Pl. 13, fig. 1). In this stage the yolk sac fills the lower half of the egg up to an horizon, (*h*,) which is nearly the same with the greatest diameter of the latter. By peeling off the shell and varnishing the shell membrane, the whole internal organization of the egg around the embryo may be as plainly seen as represented on Pl. 13, fig. 1. In fig. 10, Pl. 15, there are two embryos in one egg, but one is much smaller than the other, and considerably less developed; the larger one, however, belongs to the stage just described.

In the succeeding stage (Pl. 14, fig. 13; Pl. 15, fig. 7, 8, 8a, 9; Pl. 18a, fig. 1; Pl. 20, fig. 4, 4a; Pl. 23, fig. 3; Pl. 24, fig. 10, 10a, 10b) the embryo has assumed an erect position, having the right and left sides of the body on the same plane, and parallel with the horizon. The head is proportionately smaller, more elongated, and narrower; excepting among the Chelonii, in which it remains oblong, the shield is nearly circular.

In consequence of the elongation of the head, the brain (Pl. 23, fig. 3) is also more straightened, especially the olfactory lobes and nerves, (*c–c′*,) so that from the Schneiderian membrane (*c′*) to the cerebellum (*e*) there is a long and pretty uniform curve. The olfactory lobe (*c*) is much more enlarged, and seemingly at the expense of the hemispheres (*a*). The hemispheres (*a*) are on a level with the corpora quadrigemina (*b*). The optic lobes, (*k*,) in following the elevation of the hemispheres, are raised considerably above the floor of the fourth ventricle (*p*). The floor of the fourth ventricle (*p*) is much thicker, and the whole ventricle is proportionably larger and broader, than heretofore. The vascular covering (*g′*) of the medulla oblongata contains more bloodvessels. The entrance to the ear may be recognized externally as a large dark spot just behind and above the corner of the mouth (Pl. 18a, fig. 1). At the tip of the upper jaw there begins to appear a slight protuberance, (Pl. 18a, fig. 1,) the nature of which will be better understood in future stages.

Besides the distinctly developed pulmonary artery, (Pl. 24, fig. 10, 10a, 10b, *h′*, *h′*,) already mentioned, the heart has now a complete valvular apparatus (fig. 10b, *vo*, *vl*) between the auricles (h^3, h^3) and the ventricle, (h^4,) and a large venous sinus (fig. 10a, *vs*). The extent of the vascular area is variable, in some instances covering a large portion of the yolk, (Pl. 15, fig. 7,) and in others not more than one half (Pl. 15, fig. 8, 8a, 9) of its surface. The lungs are now many-chambered (Pl. 20, fig. 4, 4a); the partitions are traversed by bloodvessels, (*b*, *b′*, *c′*,) and new channels of blood are being hollowed in the younger partitions (*a′*). The allantois extends as far as the edge (Pl. 15, fig. 8, *i*, fig. 8a, fig. 9) of the vascular area, where it bends upon itself and passes upwards and follows the inner contour of the shell very closely. The characteristic parallel bloodvessels enable one to follow very easily the foldings of this organ (Pl. 14, fig. 13; Pl. 15, fig. 8, 8a, 9).

The skin of the neck has strong folds, (Pl. 15, fig. 9,) indicative of the retractility of the head, which the embryo possesses in a marked degree. This, consequently, indicates the existence of active retractor muscles of the head and neck. Indeed, when the egg-shell is removed, young Chelydras of this age already snap fiercely at any thing that is brought near them.

In a phase but slightly more advanced than the last, the protuberance at the end of the upper jaw (mentioned above, line 13) is here (Pl. 16, fig. 1; Pl. 25, fig. 10, *bk*) prolonged into a very prominent, sharp beak, covered by the soft and thick epidermis. The eyes are partially covered by movable eyelids (Pl. 25, fig. 10). The terminal joint of each toe (Pl. 25, fig. 12, *b*) is covered with a distinct and thick, transparent layer, (*a*,) resembling horn. The bones of the fingers (*d*) are broader at the ends than at the middle. The bloodvessels of the feet are well developed, and, starting from a transverse vessel (*e, e*) near the base of the third joint, go in pairs to each finger. In this phase the allantois has almost completely enveloped the yolk mass (Pl. 16, fig. 1).

In the next phase, (Pl. 15, fig. 1, 2, 3; Pl. 9a, fig. 30, 30a; Pl. 18, fig. 3; Pl. 19, fig. 9–12, 16b, 16c, 18, 18a, 19, 20, 21, 23, 24, 25, 26, 26a, 32; Pl. 20, fig. 1, 1a, 1b, 5, 6, 7, 8, 9, 9a, 10, 11; Pl. 21, fig. 1, 2, 3, 4, 5, 6, 7, 8, 9, 14, 14a, 14b, 14c, 14d, 14e, 14f, 14g, 15, 15a, 16, 16a, 16b, 20 to 20d, 29, 31, 32 to 32d, 34, 34a; Pl. 24, fig. 6; Pl. 25, fig. 1 to 1d, 5,) the whole contents of the egg are surrounded by the allantois, (Pl. 15, fig. 2,) and no part of the organization, except the blood, is in a loose, mobile state. Even the yolk forms a tenacious sheath about the bloodvessels, (this is figured for the next stage, Pl. 18, fig. 4, 4a,) which anastomoze with each other throughout the whole yolk sac. The yolk sac is nearly as small as when the embryo is hatched. The proportions of the body are about the same as when the embryo is born; the head is quite pointed, and the neck proportionally shorter than heretofore. The folds of the skin are more marked and numerous. The lower jaw is pointed (Pl. 25, fig. 1a, *x*). In Chelydroidæ (Pl. 15, fig. 3) the shield is marked with a median and two lateral rows of large tubercles, and numerous smaller ones all over the surface, while among Emydoidæ the shield is minutely granulated. The head, neck, legs, and tail are covered with small and rather stiff scales. The thick, transparent layer covering the terminal joints of the toes in the last phase is here developed into horny sheaths, forming sharp claws (Pl. 21, fig. 20, *a*).

The brain is composed of large, globular, transparent cells, each containing a single mesoblast; and those of the hemispheres, (Pl. 19, fig. 16b, 16c, *a, b, b', c, c'*,) of the olfactory lobes, (fig. 18, *a*,) of the Schneiderian membrane, (fig, 19, *a, b*,) of the medulla oblongata, (fig. 20, *a, b*,) and of the spinal cord, (fig. 21,) have all one common physiognomy. Already there are a few slightly caudate cells, (fig. 18, *a*, fig. 19, *a*,) and those of the Schneiderian membrane (fig. 19) are mutually pressed against each other. The eyes have fully developed eyelids (Pl. 15, fig. 3). The crystalline lens (Pl. 21, fig. 29) is covered in front by a large layer of polygonal cells, (*a*,) the "membrana pupillaris," which is overlapped by the anterior edge of the membrana hyaloidea, the zonula Zinnii (*c*). The zonula Zinnii (*c*) has the longitudinal plications, the ciliary processes of the membrana hyaloidea, as fully developed perhaps as in the adult. At the anterior edge of the zonula, the pigment layer (*b*) is quite thick. The cells (Pl. 21, fig. 32a, *a, b, c, d*) of the fibres of the crystalline lens are so excessively transparent and closely adherent to each other, that it is difficult to recognize each separately; and, in fact, in some parts of the lens, their walls appear to be obliterated at the point of contact, so that they form a continuous ribbon (Pl. 21, fig. 32b, 32c). These bands traverse the whole thickness of the lens, and converge toward its two opposite sides (Pl. 21, fig. 31, 32, *a*).

The shape of the blood corpuscles varies; some are quite flat, (Pl. 19, fig. 12, *a*, *b*,) and others are more or less thick, (fig. 10, *a*, *b*, *c*, *c'*,) and even perfectly round when seen endwise (fig. 11, *c*, *d*). The liver is strongly bilobed and very much flattened (Pl. 25, fig. 1, *r*, *r*); and at one point (fig. 1a, *r*) it clings very closely to the stomach (fig. 1a, n^3). The cells (Pl. 19, fig. 32, *a*, *b*, *b'*, *c*, *c'*) of the liver are as characteristic as in the adult, with their large mesoblast, coarse, granular contents, and strongly polygonal shape (fig. 32).

The partitions of the lungs are very numerous, (Pl. 20, fig. 5,) and have a distinct fibro-muscular structure (fig. 10, *b*, fig. 11, *b*); the cells of the epithelial layer (fig. 9, *a*, fig. 11, *a*) are broad and deep. The surface of the lungs is covered with a layer of very faint, round cells, (fig. 9a and 11,) with minute granules interspersed between them; and, along the courses of the bloodvessels, there are numerous black pigment cells (fig. 5, 8, and 11, *b'*). The cartilaginous rings of the trachea (Pl. 24, fig. 6) form a nearly continuous spiral; the cartilage cells of this organ are sharply polygonal, and as yet pretty close together (Pl. 20, fig. 6).

The intestine (Pl. 25, fig. 1, n^1, n^2, fig. 1a, n^1, n^2, n^4) is very long and much convoluted; its anterior opening is furnished with a well developed hyoid bone (fig. 1a, *oh*); the neck (fig. 1, n^7) of the yolk sac, where the intestine connects with it, is very small and scarcely perforated. The folds of the internal surface of the œsophagus (Pl. 25, fig. 1b) are broad, and have narrow but deep intervals; but at its posterior part the folds widen considerably as they pass into those of the stomach, where the intervals are very narrow and shallow. Just behind the stomach the folds are very narrow and wavy, and the intervals are broad, but rather deep (fig. 1c). In the thick intestine, close to the cloaca, the internal folds (fig. 1d) are almost as narrow as those in the small intestine just behind the stomach, but perfectly straight; and the intervals are very broad. Throughout the whole length of the intestine there is a well-developed, thick epithelial layer of polygonal cells, (Pl. 21, fig. 1, 3, 4, 5, *a*, 6, 14a, 14b, 14c, 14d, 14e, 14f, 14g, 34,) covered with vibratile cilia, and beneath this layer a thick stratum of long, columnar cells, either in a single layer, (fig. 2 and 5, *b*,) or, in the thick intestine, in two or three layers (fig. 34). The whole surface of the stomach is marked by little apertures, (fig. 14, *a*, 14a, 14b, fig. 15, 15a, *b*,) leading into quite deep depressions or sacs, (fig. 16, 16a, 16b,) which are lined with a continuation of the epithelial layer (fig. 16b).

The uriniferous tubes (Pl. 25, fig. 5, *b*) of the kidneys are a great deal thicker than those (*a*) of the Wolffian bodies. The uriniferous tubes (Pl. 20, fig. 1, 1a, 1b) of the Wolffian bodies are composed of very large and transparent cells. The neck of the allantois, in the interior of the body, has swollen, and forms a broad, pear-shaped sac, (Pl. 25, fig. 1, n^6, fig. 1a, n^6,) the urinary bladder. The tissue of the exterior portion of the allantois is composed of very large and thick-walled but transparent cells, (Pl. 9a, fig. 30, 30a; Pl. 18, fig. 3,) with multitudes of faint granules for contents (Pl. 9a, fig. 30). The muscles in various parts of the body are in different degrees of development; those of the foreleg are highly, but not fully, developed, and show a very distinct fibrillous structure (Pl. 19, fig. 25, *a*, *b*); those of the dorsal arch (Pl. 19, fig. 23) are as yet composed of more or less elongated cells, (*a*, *b*,) each of which contains a single large granulated mesoblast; these cells resemble very much the cartilage cells (*c*) of the dorsal arch. The tendons in the legs have a marked fibrous structure (Pl. 19, fig. 26, 26a).

The cells of the terminal bone (Pl. 21, fig. 21) of the toes are quite large and sharply polygonal, and each contains a large mesoblast and several entoblasts (fig. 21a). The cells of the horny sheath (fig. 20, *a*) of the claw are very large, irregularly polygonal, and transparent, and contain a single small mesoblast (fig. 20a, 20b, 20c). The cells of the skin at the base of the claws, (fig. 20, *b'*,) and those (*b*) which continue under it, are quite large, polygonal, and each contains a single mesoblast and entoblast, besides a few scattered granules (fig. 20d).

The next phase (Pl. 18, fig. 2, 4, 4a, 10, 10a, 10b, 10c, 10d, 10e, 10f; Pl. 25, fig. 3, 3a, 7, 7a, 9; Pl. 19, fig. 27, 27a, 29, 29a, 30, 31, 33, 34, 35, 35a; Pl. 20, fig. 18; Pl. 22, fig. 5, 6, 6a, 6b) is the last before the embryo is hatched. A few external features, peculiar to certain families, and not noticed in the last phase, require now to be noticed; otherwise there is not any appreciable difference in the external appearance of the embryo. By this time the shield of many of the Emydoidæ is covered by a beautiful granular embossment (Pl. 18, fig. 10d, 10e, 10f). The embryo, at the same time, is perfectly straight, in all oval eggs, (Pl. 18, fig. 10, 10a, 10b, 10c,) and not bent upon itself, as happens in round eggs (Pl. 15, fig. 1, 2). In the latter case, at least among Chelydroidæ, the embryo has not the power to retract its head or feet, except for a short distance; whereas in Emydoidæ only two thirds of the head projects beyond the shield, and the feet are hidden under the latter, and the edge of the shield is very much bent downwards when the embryo is ready to hatch. The beak, (Pl. 25, fig. 9, *bk*,) in all Turtles, is very prominent and sharp. The eyes may be closed as readily as in the adult. The cells of the epidermis (Pl. 20, fig. 18, right half) are large, sharply polygonal, and have thick walls. Underneath the epidermis is a layer of very large, thin walled, excessively hyaline, polygonal cells, each containing a large patch of pigment of a more or less deep black color (fig. 18, left half). The heart, (Pl. 25, fig. 3, *h*,) the liver, (fig. 3, *r*, *r*, fig. 3a, *r*, *r*,) the intestine, (fig. 3, n^3, 3a, n^3,) and the lungs, (fig. 3a, *l'*,) are in nearly the same condition as in the last phase.

Soon after hatching, this Turtle discharged from its intestines a glutinous matter with green blood discs, (Pl. 19, fig. 35,) more or less broken up, and also bodies which appear to be crystals of uric acid (fig. 35a, *a*, *b*, *c*, *d*, *e*).

Each of the lungs (Pl. 25, fig. 3a, *t'*) occupies as yet a small space, close upon the back of the liver (*r*, *r*) and of the heart. The surface of the lungs is quite dark with pigment cells. The cells (Pl. 19, fig. 31, *a*, *b*) of the liver are similar to those of the last phase. The cells (Pl. 19, fig. 29, 29a) of the gall cyst are broad, long, and columnar, each containing a single large mesoblast. The wall of the cyst consists of only a single layer of these cells, which, seen in the direction of their length, appear polygonal. The contents of the gall cyst (Pl. 19, fig. 33, 34) are, in a great measure, minute, dark granules, with bodies that appear to be the different stages of growth of blood corpuscles. The Wolffian bodies and kidneys (Pl. 25, fig. 3a, *q*, fig. 7, 7a) are quite broad and short, with blunt ends; the former are about equal in size to the latter. The kidneys (fig. 7, *b*, 7a, *b*) are supplied with numerous bloodvessels. The generative organs (fig. 7, *n*) are much broader and shorter than when we first noticed them, and do not equal the length of the kidneys. The cells (Pl. 19, fig. 30) of the female generative organ, the ovary, (Pl. 25, fig. 7, *n*,) are moderately large and sharply polygonal, and each cell contains a large, granulated mesoblast.

The bloodvessels of the omphalo-meseraic system occupy the whole yolk sac, in the form of close meshes, (Pl. 18, fig. 4,) encased in a thick, tenacious layer of albuminous substance, containing innumerable yolk cells of various sizes (fig. 4a). These anastomozing vessels belong to the return currents, and have quite thick walls, (fig. 4a,) which form a striking contrast with the excessively thin walls of the efferent vessels (fig. 2) of the superficial portion of the vascular area. The superior retractor muscle of the head has afforded excellent material to show the serial arrangement of granular bodies in the formation of muscular fibrillæ (Pl. 19, fig. 27, 27a). The central cartilage cells (Pl. 22, fig. 5, 6, 6a, 6b) of the clavicle are widely separated from each other, and, judging from the branching nature of their contents, have begun to form a deposit of lime. The lower jaw (Pl. 9c, fig. 11, 11a) has a considerable amount of lime deposited in its peripheric parts, especially along its upper edge. Upon making an oblique section of its length, (through *—* fig. 11a,) a row of small cavities (fig. 11, *b*, fig. 11a, *b*) are seen proceeding from the upper side of the cavity (fig. 11, *a*, 11a, *a*) in which the maxillary nerve runs; and each little cavity is filled by a prolongation of the maxillary nerve. One would suppose that these cavities were the future sockets of teeth, did we not know that Turtles possess nothing of the kind. However, we cannot doubt that they are typical tendencies toward the development of dental organs of mastication. The suture of the branches of the lower jaw is very loose; it is formed by four or five triangular projections (fig. 11, *d*) on one side, dovetailing with a similar number of projections of the opposite side.

In the process of hatching, the young Turtle does not tear open the allantois, but simply forces apart the edges of the folds which inclose the head (Pl. 18, fig. 10o); but as the allantois is very tender at this time, it is more or less torn in the struggles of the animal to escape from the shell. The shell always breaks close to the end of the head, corresponding to the position of the sharp, hard beak (Pl. 9c, fig. 6 and 8). At this stage the yolk sac occupies about one fourth of the cavity of the shell. Before leaving the shell, the yolk sac is more or less flattened vertically (Pl. 18, fig. 10, 10b, 10c); but as soon as it is relieved of the pressure of confinement by the casting of the egg-shell it assumes a globular form, (fig. 10d, 10e,) but with less bulk external to the Turtle, a portion having been drawn into the body almost as soon as the hatching was finished. In a few hours the whole yolk sac (Pl. 25, fig. 3, n^7) is drawn into the body, and occupies a large space in the abdominal region. The circulation of the blood in the yolk sac at this time is as active as ever. The external remains of the allantois (fig. 3, n^6) are soon withered and dried, and finally, in two or three days they disappear; within the body, however, the neck of the allantois persists and becomes the urinary bladder, as mentioned above (p. 571–572). In a previous section (Chap. 1, Sect. 6, p. 486–489) we have already mentioned the persistency of the embryonal membrane, which may be recognized by its cells, (Pl. 9a, fig. 31, *a*, 31a, *a*,) along with those of the amnios (*b*) and of the allantois, (*c*,) till the embryo is hatched.

On account of the great amount of material that had accumulated, and the pressure of time, it was found impossible to investigate the state of all the organs just at the time the young Turtles were hatched. However, this did not interfere with the proper appreciation of the degree of development of these young animals about the time of hatching, since, almost from the time they were born till the space of four months had passed over, they remained in a state of torpor, being kept in a cold room, where at times they were frozen with the water in which they were preserved. During this time they evidently did not grow to any appreciable amount, since, as late as December 13th, two months after they were hatched, the yolk sac was not resorbed, but occupied a large portion of the abdominal cavity. Moreover, specimens were obtained from the fields as late as December which were not even hatched; so that no great dependence can be placed on the age to determine the stage of development. The successive phases of growth must therefore be determined by their sequence, rather than by the time required for their development. The following figures

(Pl. 17, fig. 1; Pl. 19, fig. 14, 15, 16, 16a, 17, 17a, 17b; Pl. 20, fig. 3, 13, 13a, 14, 14a, 15, 16, 17; Pl. 21, fig. 10, 11, 12, 13, 13a, 17, 18, 18a, 18b, 18c, 19, 33, 33a; Pl. 22, fig. 1, 1a, 1b, 2, 3, 3a, 4, 4a, 8, 8a; Pl. 23, fig. 4, 4a, 5, 6, 7, 8, 9, 10, 11) represent the condition of the young Turtles during a period extending over nearly three months and a half after they were hatched. The organs of but one species (Chelydra serpentina) are represented here.

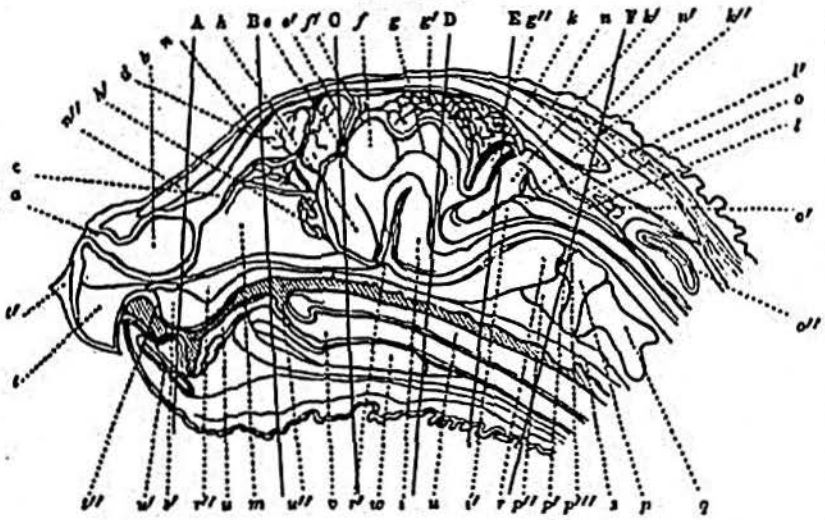
The cavity of the intestine (Pl. 17, fig. 1) is totally shut off from the yolk sac, but the wall of the former is not detached from it. There are two distinct muscular coats (Pl. 21, fig. 11, *d*, 18, *c*, *d*, 19, *c*, *d*) in the intestine, the fibres of which run transverse to each other. The cells of the muscular layer (Pl. 21, fig. 11, *d*) of the œsophagus are excessively long, and tapering at each end (fig. 13, 13a). The epithelial layer of this part of the intestine is more compact (Pl. 21, fig. 11, *a*, *b*). At the base of the tongue there are no vibratile cilia, (Pl. 21, fig. 10,) but the cells resemble those at the posterior end of the intestine (Pl. 21, fig. 18, 18a, 18b, 19). The glands of the stomach are considerably elongated and convoluted, (Pl. 21, fig. 17,) and the wall (*c*, *d*) of each is very thick, being composed of three or four layers of cells, continuous with the epithelial layer (*a*) of the surface of the stomach. The epithelial layer of the long intestine (Pl. 21, fig. 18, 18a, 18b, 18c) and of the rectum (Pl. 21, fig. 19) is now composed of five or six layers of superposed cells. The cartilaginous rings (Pl. 20, fig. 3, *b*) of the windpipe are much broader than the intervening fibrous tissue (*a*). The cartilage cells (Pl. 20, fig. 3, *b*) are widely separated from each other, just as in all permanently cartilaginous bodies. The epithelial cells (Pl. 20, fig. 13, 13a, 15) of the urinary bladder can hardly be distinguished from those of the long intestine and of the rectum. The muscular walls (Pl. 20, fig. 16) of the bladder are highly developed; the fibres are very distinct, and run in every possible direction. The cells of the smooth muscles of this organ vary in their proportions at different depths (fig. 14, 14a); those more interior being the longer ones. The contents of the bladder, seen by incident light, have a dead white color, by transmitted light a fuscous color; and consist principally of large, dead white flakes, (fig. 17,) composed of very minute granules, and a few bodies which appear to be epithelial cells, in various stages of decomposition.

The brain (Pl. 23, fig. 4, 4a, 5, 6, 7, 8, 9, 10) fills the cranial cavity as completely as in the adult. It is more elongated, and not so deep, as in the last stage (Pl. 23, fig. 3). The Schneiderian membrane (fig. 4, 11, and woodcut 3, *b*, w-c.[1] 11, *a*) is more expanded vertically, and the olfactory nerve (fig. 4,

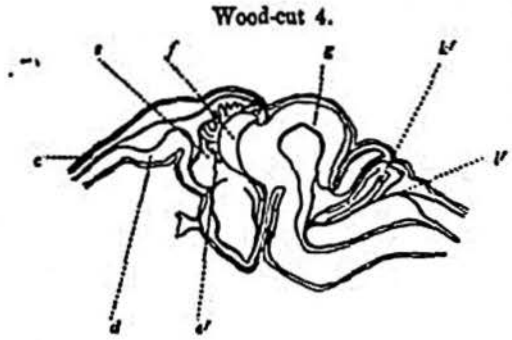
[1] In these references, "w-c." is the abbreviation for wood-cut.

4a, w-c. 3, c, w-c. 4, c) is much larger and longer. The olfactory bulb (fig. 4, 4a, 10, w-c. 3, *d*, w-c. 4, *d*, w-c. 10, *a*, *a'*) is distinctly striated by broad bands of white and gray matter; and it is more enlarged, and encroaches still more upon the rather diminished hemispheres, (fig. 4, 4a, 8, w-c. 3, *e*, w-c. 4, *c*, w-c. 8, *a*) than before. The cavity of the latter is nearly filled by the choroid plexus (fig. 4a, 8, w-c. 4, *e*, w-c. 8, *d*); and the optic lobes (fig. 4, 4a, 8, 9, w-c. 3, *h*, w-c. 8, *f*, *f'*) are again on a little higher level than the fourth ventricle, (w-c. 3, *i*,) and advanced so as to underlie the greater part of the hemispheres (fig. 4, 4a, 8, w-c. 3, *e*, w-c. 4, *e*, w-c. 8, *a*). The optic nerve (fig. 4, 4a, w-c. 3, *h'*) is as yet very short, passing almost immediately from the optic lobe into the eye. The pineal gland (fig. 4, 4a, w-c. 3, *f*, w-c. 4, *f*) is a solid mass, sunk considerably below the upper surface of the hemispheres and of the corpora quadrigemina. The crura cerebri (fig. 8, 9, w-c. 8, *a''*) are already quite prominent. The corpora striata (fig. 8, 9, w-c. 8, *a*, w-c. 9 *a*) project considerably into the cavity of the hemispheres. The corpora quadrigemina (fig. 4, 4a, 7, w-c. 3, *g*, *g'*, w-c. 4, *g*, w-c. 7, *a*, *a'*) have much thicker walls, and are more sunk posteriorly toward the fourth ventricle. The cerebellum (fig. 4, 4a, 6, w-c. 3, *k*, w-c. 6, *a*, *a'*, *a''*) is very much enlarged; it has a much thicker wall, and trends almost perpendicularly to the axis of the brain, upward from its anterior border (w-c. 6, *a''*). The arach-

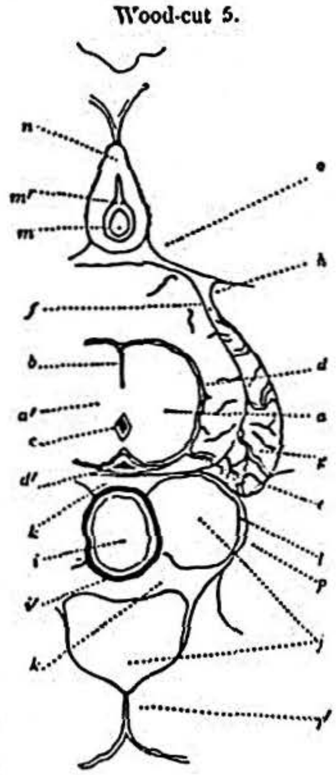
Wood-cut 3.



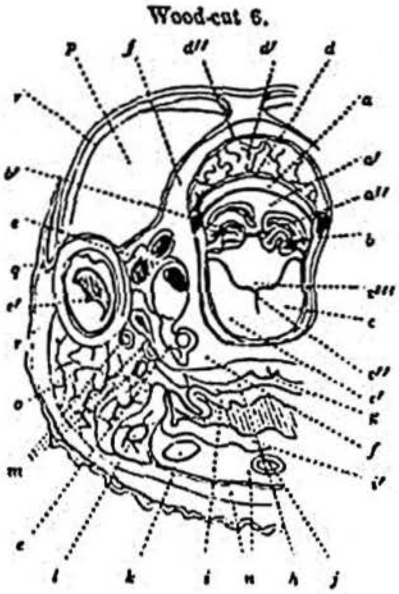
Wood-cut 4.



Wood-cut 5.

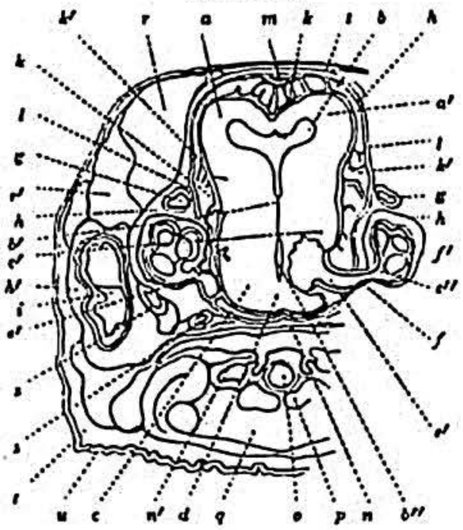


Wood-cut 6.

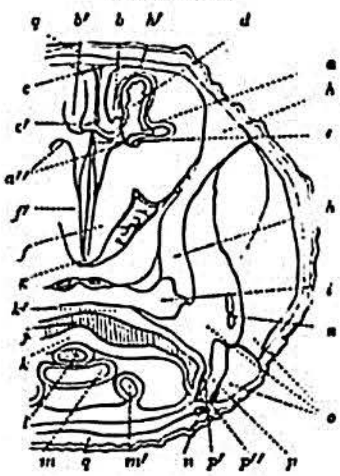


noid plexus has become a large and dense bunch of bloodvessels (fig. 4, 4a, 6, w-c. 3, *k'*, w-c. 4, *k*, w-c. 6, *b*, *b'*) hanging in the cavity just below the cerebellum. The spinal marrow (fig. 4, 5, w-c. 3, *l*, w-c. 5, *a*) has closed over, close up to the medulla oblongata, (fig. 4, 6, w-c. 3, *i'*, w-c. 6, *c*, *c'*,) but the latter remains broadly open. The whole surface of the brain, above and below, is covered by a delicate membrane, filled by a dense network of bloodvessels (fig. 4, 5, 6, 7, 8, 9, 10, w-c. 3, *g' g''*, w-c. 5, *d*, w-c. 6, *d*, w-c. 7, *k*, w-c. 10, *c*): this is the pia mater. The cells of the tissue of the olfactory nerve are beginning to unite with each other in a linear series (Pl. 19, fig. 15) to form nervous tubes. The tissue cells of the base of this nerve, close to the olfactory bulb, are sharply polygonal (Pl. 19, fig. 17, 17a, 17b) and elongated. The cells of the cerebrum are not so regularly polygonal as at the base of the olfactory nerve, but still retain more or less of their original rounded contours (Pl. 19, fig. 16, *c*, 16a). The eyes are (Pl. 21, fig. 33, 33a; Pl. 22, fig. 8, 8a) perfectly developed, as far as the requirements of sight are concerned, excepting some features of secondary importance: the bony ring (Pl. 22, fig. 7, *c*) in the sclerotica, (*b*,) and the double membrana pupillaris (*n*, n^1) before the capsule of the lens, (*l*,) in the adult, are not yet apparent. (See fig. 8, *b*, the sclerotica, and *n*, n^1, the membrana pupillaris.) The ears (Pl. 23, fig. 6, 7, w-c. 6, *c*, *c'*, w-c. 7, *i*, *f*) have nearly as complicated a labyrinth as in the adult.

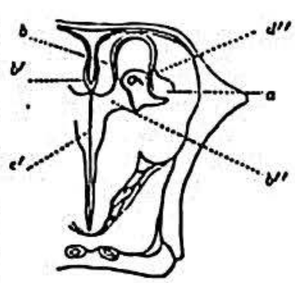
Wood-cut 7.



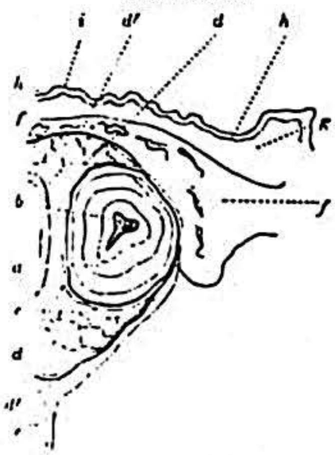
Wood-cut 8.



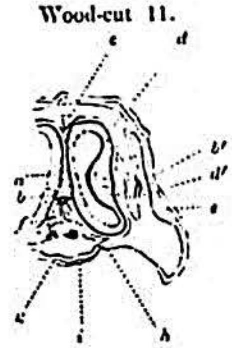
Wood-cut 9.



Wood-cut 10.



Wood-cut 11.



The amount of ossification of the bones is very unequal in different parts of the body. The vertebral column (Pl. 23, fig. 4, w-c. 3, *q*) and the bones of the sternum are the most advanced in this respect, two thirds of the bone at least being hardened, mostly next the surface. The bones of the upper jaw (Pl. 23, fig. 4, fig. 11, w-c. 3, *t*, w-c. 11, *e*, *d*) are perhaps as much ossified as those of the vertebral column. The bones of the toes come next in the series, the ossification here being principally along the cylinder. The other bones of the limbs are much less ossified. The ribs have already a broadly winged margin (Pl. 9e, fig. 12, *b*); there is only a thin layer of bony substance at the surface, near the base of attachment to the vertebræ; the rest of their length is densely fibrous, (Pl. 9e, fig. 12, *b* to *b*; Pl. 22, fig. 1, *b*, *c*, *d*, *e*, fig. 2, *c*, *d*, *e*, *f*,) with a cartilaginous interior (Pl. 9e, fig. 12, *a*, *a′*; Pl. 22, fig. 1 and 2, *a*, a^1, a^2, a^3). The skin, corium, (Pl. 9e, fig. 12, *c*, *c′*; Pl. 23, fig. 4, 6, 7, 8, 10; and w-c. 6, *r*, w-c. 7, *t*, w-c. 8, *q*, w-c. 10, *g*,) is a very dense layer of thickly matted, fine, white fibres (Pl. 22, fig. 1, *g*, *g′*, *h*, h^1); it is thickest between the ribs. Throughout its thickness there are scattered groups of pigment granules, and a short distance below the epidermis there is a dense, uniform layer of these pigment granules, (Pl. 9e, fig. 12, *h*,) which seems to be a dividing line between the corium (fig. 12, *g*) and the epidermis; but this is not so, for the epidermis (Pl. 20, fig. 18) is a very thin film, here (Pl. 9e, fig. 12) represented by a black line, between which and the pigment stratum there is a moderately thick layer of fibrous substance, (fig. 12, *i*,) which, to all appearances, is identical with, and merely a continuation of, the corium.

This is sufficient, in a general point of view, to characterize the young Turtles at the time of hatching; especially if, to avoid repetition, we refer to a previous section, (Part II., Chap. 1, Sect. 14, p. 290,) on the development of Turtles from a zoölogical point of view, and to another, (Part II., Chap. 3, Sect. 4, p. 386,) on the comparison of the growth of the Chelonii with that of the Amydæ, in which the young of several species, belonging to different families, are described at that age. In the next section, further details concerning the development of several organs will be given, and this, with the section on the Histology of the embryo, will complete the account of our observations respecting the origin and mode of growth of the Turtles. One single general remark, however, may with propriety find place here, before we proceed to these specialities.

The great wonder, in the development of all organized beings, consists in the differentiation of the substance in the different parts of the same body, while it remains under identical influences. This evidently takes place under the action of that principle, in virtue of which every animal is an individual of some special kind of animals, and not in consequence of any physical agency. The living egg makes its own different substances because it lives, and not in order that a new animal may grow up. This has an important bearing upon the general question of the nature and origin of matter. Without approaching this subject in detail, I would only express my belief, that matter does not exist as such, but is everywhere and always a specific thing, as are all finite beings.

SECTION VIII.

FORMATION AND DEVELOPMENT OF THE ORGANS.

While tracing the general progress of the development of the young Turtle, we have described with sufficient fulness the mode of formation and the earlier metamorphoses of many of the organs;[1] and it would therefore be useless to repeat here many of these descriptions, now that we are about to consider the different organs and systems of organs separately. It will be sufficient for our purpose to refer to the figures and pages, in which much that might be required here has already been said, and then to fill up whatever blanks may be left, in order to illustrate the serial development of each organ. As we proceed in the description of these organs, we shall refer to the pages where they are mentioned in connection with the whole embryo; and in this way every student may be enabled, not only to follow the progressive growth of each organ, but also to appreciate the relations which every one bears to every other, at each successive stage of its special development.

The Brain. The formation of the primitive furrow, which is the earliest step taken to lay the foundation for the brain and spinal cord, has already been described (p. 543, Pl. 9c, fig. 3, *b*, fig. 3a, *b*, fig. 4, *b*, fig. 4a, *b*; Pl. 11, fig. 3. *b*, fig. 4, 5, *b*). This primitive furrow soon becomes a deep gutter, of variable width and depth. In the head it is a very broad channel, from the beginning of its formation; but soon the germinal layer rises on each side of it in the form of a long ridge, in consequence of which the channel (Pl. 12, fig. 1a, e^1; Pl. 9d, fig. 1, e^1, e^6) is deepened. Gradually the ridges rise higher and higher, till the channel is as deep as it is broad; they then fold inwardly toward each other till their edges meet, first at one point, (Pl. 9d, fig. 1, e^3,) and finally along the whole length of the head, (Pl. 12, fig. 3, e^1,) thus forming a large, closed cavity (see p. 547). At this period, the cavity occupies the whole breadth of the head. as well as its whole length; the vertebral layer not being developed, except along the lower side of that organ (see Pl. 9d, fig. 1, f^1).

At the posterior end of the head, the brain gapes broadly open (Pl. 12, fig. 8, e^2, fig. 9, e^2, fig. 9a, e^2) for a considerable distance, as far back as just above the heart. where it again closes over rather suddenly as it meets the spinal tube

[1] Comp. p. 513–578.

(fig. 9, *e*, fig. 9a, *e*). Subsequently, this opening lessens considerably, but is never closed, not even in the adult. At this period, the position of the brain in relation to the spinal cord is remarkable: the whole of this organ, with the exception of a small portion, the cerebellum, (Pl. 12, fig. 8, e^3, 9, e^3, 9a, e^3,) next to the open region, trends in a direction which is perpendicular to the spinal marrow (fig. 9, 9a, *e*). At no other time is the brain so strongly bent upon itself. Thus far there is but one fold, that at the cerebellum; the latter forming the angle of junction between the brain and the medullary tube, and all that is to be hereafter—severally, the olfactory lobes, the hemispheres, the optic lobes, and the corpora quadrigemina—is now comprised in a simple, large chamber, which stands in the most deflected position conceivable, at right angles to the longitudinal axis of the body.

Subsequently, the brain suddenly narrows behind, (Pl. 12, fig. 10, e^3,) and folds downward and forward along the median line, so as to give its posterior edge a heart-shaped figure; and thus the posterior boundaries of the corpora quadrigemina are formed. We have given a perfect profile view of an embryo a little older, in order to show the transverse position of the brain as regards the spinal axis (Pl. 12, fig. 6; Pl. 18a, fig. 13). Soon after this, the superior or dorsal side of the brain becomes indented by two transverse, shallow folds, so as to have an undulated profile (Pl. 18a, fig. 14). This produces a slightly three-lobed aspect; one lobe being anterior to the folds, one between them, and one behind the same; the last lobe, the corpora quadrigemina, (fig. 14, e^3,) is clearly separated from the open region (fig. 14, e^1) behind by a folding, which we have described in the last phase. These folds increase in depth, and plunge far into the head; the posterior one (Pl. 24, fig. 7, e^5) reaching much deeper than the anterior one, which is just in front of the eyes (fig. 7, *k*). The breadth of the brain, at this stage, has decreased considerably, (Pl. 24, fig. 7a, e^2 to e^8,) and is slightly undulating at the sides, so as to appear four lobed when seen in front: the anterior lobe, formed by the hemispheres, (fig. 7a, e^8,) being the same as the one seen before the eyes in the profile view (fig. 7); the second, the optic lobe, is that which lies just in front of the deepest fold (fig. 7, e^6); the third lobe, formed by the corpora quadrigemina, is that which lies close behind the deepest fold; and the fourth and last lobe (fig. 7, e^2) is the cerebellum. The lateral constriction, between the optic lobes and the corpora quadrigemina, soon becomes very deep, (Pl. 24, fig. 9a, e^6,) and the latter body is gradually elevated, (Pl. 14, fig. 4; Pl. 16, fig. 6 and 6a,) so as to give the head a crested appearance. This crest rises at one time very high (Pl. 14, fig. 2a; Pl. 18a, fig. 9). However, the prominence of the corpora quadrigemina does not indicate an absolute preponderance in size or capacity, when compared with the other lobes, since we find, upon taking a view of the interior (Pl. 22, fig. 9, *b*) of this body, that its lower floor is folded inward and upward so as to occupy the larger part of the space included within its superior arch. At this time, the inferior side of the optic lobes has a very thick wall, and is very much compressed; it descends far down between the eyes, (Pl. 22, fig. 9, *c*,) and has a very narrow space between its opposite walls. The extreme anterior end of the brain, the hemispheres, (Pl. 22, fig. 9, b^1,) has very thick walls and a broad cavity. The two opposite halves of the end of the hemispheres are not intimately soldered together in one continuous layer, but merely touch each other. The superior or rather external edges of these two halves are folded inward, (fig. 9, b^2,) so as partially to divide the cavity of the hemispheres. This is the first indication of the development of the two olfactory nerves. Next, the superior wall of the optic lobes begins to bulge out between the eyes, (Pl. 15, fig. 13,) and forms a continuation (Pl. 24, fig. 11) of the crest of the corpora quadrigemina, but at a much lower level. The hemispheres are more prominent than before, and encroach upon the anterior portion of the optic lobes, overlapping them at the sides and above.

The hemispheres continue for a while to go on enlarging rapidly, (Pl. 23, fig. 1, *a*, fig. 1a, *a*,) and encroaching upon the optic lobes (fig. 1, *k*, fig. 1a, *k*). This causes the head to bulge very much just above the eyes, (Pl. 14, fig. 1; Pl. 15, fig. 12, fig. 12a,) and renders it angular in outline. From the hemispheres to the tip of the head, (Pl. 23, fig. 1, *c* to *c*′,) the brain becomes very much narrowed, and tubular in form, assuming the character of an olfactory nerve, with a suddenly expanded terminal portion, (fig. 1, *c*′,) the Schneiderian membrane. In consequence of the bulging of the hemispheres, the anterior part of the brain does not trend at right angles to the spinal marrow, but forms an arch, which, however, may be said, in general terms, to run at right angles with the axis of the body. The olfactory nerves, (Pl. 23, fig. 1, *c* to *c*′,) in this case, meet the hemispheres (fig. 1, *a*, fig. 1a, *a*) nearly at right angles. As yet the olfactory nerves are quite short and thick. The folds of the two halves of these nerves, mentioned above, (Pl. 22, fig. 9, b^1, b^2,) are here closed, (Pl. 23, fig. 1a, *c*,) and form two distinct olfactory tubes. This inward folding of the anterior part of the brain is continued backward to the hemispheres, along the median line, so as to divide them into two equal portions, one on the right, (Pl. 23, fig. 1a, *a*.) and another on the left (fig. 1, *a*). The infolding edges of the hemispheres (fig. 1a, *m*) are not closed over at this time, but leave a large aperture on that face of each half which is next to the median line. The superior side of the optic lobes, (fig. 1, *k*, fig. 1a, *k*.) where they meet the hemispheres, becomes transversely folded downward and backward, so as to form a small, rounded mass, (fig. 1, *d*, fig. 1a, *d*,) attached by a broad base to the superior portion of the optic lobes. This new body is the pineal gland, and bears a very large proportion to the bulk of the whole brain, when compared with its size in the adult (Pl. 25, fig. 13, *pg*).

That part of the brain which lies close behind the corpora quadrigemina, (Pl. 23, fig. 1, *b*, fig. 1a, *b*,) and extends at right angles to them, becomes at this time more prominent (fig. 1, *c*, fig. 1a, *c*) than the region posterior to it (fig. 1, o^1, fig. 1a, o^1). This, unquestionably, is the cerebellum, since just behind it we find that part of the spinal marrow, the medulla oblongata, from which the auditory nerve (fig. 1, *l*, fig. 1a, *l*) arises. The medulla oblongata (fig. 1, o^1, fig. 1a, o^1) bends downward and forward so as to run nearly in the same direction with the cerebellum (*c*). The cavities of the corpora quadrigemina, (fig. 1a, *b*,) of the cerebellum, (*c*,) and of the medulla oblongata, (o^1,) open widely into each other; but between the two lobes of the hemispheres (fig. 1, *a*, fig. 1a, *a*) and the optic thalami (fig. 1, *k*, fig, 1a, *k*) there is no communication whatsoever, nor between the latter and the corpora quadrigemina (fig. 1, *b*, fig. 1a, *b*). The optic thalami (fig. 1a, *k*) remain adherent to each other at the lower border by means of a thin commissure, which is continuous with the floor of the fourth ventricle, (*o*,) and also with that between the anterior border of the corpora quadrigemina (*b*). The floor of the fourth ventricle, (fig. 1a, *o*,) which was formerly spoken of as the lower floor of the corpora quadrigemina, and pointed out as folding upward and nearly filling the latter, (Pl. 22, fig. 9, *b*,) has become depressed, so as to leave a very large cavity in the corpora quadrigemina. Presently the olfactory nerve elongates, (Pl. 23, fig. 2, *c*, c^1, fig. 2b, *c*, c^1,) and swells at its base, (fig. 2, *c*, fig. 2b, *c*,) indicating the first step in the development of the olfactory bulb. The Schneiderian membranes (fig. 2, c', fig. 2a, c', fig. 2b, c', fig. 2c, c'') are separated by a cartilaginous partition (fig. 2c, c'''). The hemispheres (fig. 2, *a*, fig. 2a, *a*, fig. 2b, *a*) increase in size in a much greater proportion than the other lobes, and gradually rise until they are on the same level with the corpora quadrigemina. The crura cerebri (Pl. 23, fig. 2d, *r*) arise by a thickening of the lower wall of each hemisphere along its whole length, close to the median line of the brain. The aperture (fig. 2b, *m*) next to the median line becomes very much reduced in size. The pineal gland (fig. 2a, *d*, fig. 2b, *d*) is about two thirds covered by the hemispheres, (fig. 2, *a*, fig. 2a, *a*, fig. 2b, *a*,) which overlap it at the sides. This body is not solid throughout, but has a slight excavation on its posterior face, in open communication with the cavity of the corpora quadrigemina (fig. 2, 2a, 2b, *b*). The optic thalami, (fig. 2, k', fig. 2b,) in consequence of the encroachment of the hemispheres, (*a*,) have become totally confined to the lower side of the brain. In the brain of the Turtle, at this age at least, and even in the last phase, (Pl. 23, fig. 1, 1a,) it is very evident that the optic nerves (fig. 2, *k*, fig. 2b, *k*) arise directly from the optic thalami, (*k'*,) and not from the corpora quadrigemina, (*b*,) as would appear from the figures of the adult brain given by Bojanus.[1]

The corpora quadrigemina (fig. 2, *b*, fig. 2a, *b*, fig. 2b, *b*) gradually lose their large, open cavities, in consequence of the elevation of the lower floor, the aquæductus Sylvii, (fig. 2b, *o*,) of this part of the brain. The volume of the corpora quadrigemina, (fig. 2, *b*, fig. 2a, *b*, fig. 2b, *b*,) compared with that of the hemispheres, (fig. 2, *a*, 2a, *a*, 2b, *a*,) is at this time about as two to three, which is a very large proportion, compared with what it is in the adult (Pl. 25; compare fig. 13, *cq*, fig. 13a, *cq*, with *h*). The corpora quadrigemina are heart-shaped, with the broader end next to the hemispheres, which have a similar shape, but in a reverse position from that of the former.

The cerebellum (fig. 2, *c*, fig. 2a, *c*, fig. 2b, *c*) continues to bulge out behind the corpora quadrigemina, and to gain in bulk, but at a slow rate when compared with the other parts of the brain. The Schneiderian membrane enlarges more rapidly in a vertical direction (Pl. 23, fig. 3, *c'*) than horizontally, and becomes gradually compressed, at the sides, so as to contain a very high but narrow chamber. The exterior opening of the cavity of this membrane first appears as a narrow channel (fig. 3, *9*) with a very thin wall. The pineal gland (fig. 3, *d*) becomes constricted at its base, and thus the first step is taken to form its pedicel. The corpora quadrigemina (fig. 3, *b*) become more constricted and depressed at the base behind, and in consequence more shut off from the cerebellum (fig. 3, *e*). The latter, in continuing to increase in size, gradually bends obliquely upward, so as to cover by degrees a considerable portion of the fourth ventricle (fig. 3, *p*). The fourth ventricle, (fig. 3, *p*,) by bending forward upon itself, allows the cerebellum (*c*) and the posterior end of the corpora quadrigemina (*b*) to sink into the angle formed by its approximating anterior and posterior borders. The edges of the opening (fig. 3, *e'*, *f*) of the medulla oblongata grow thicker, until in time they equal in this respect its lower wall.

At the time the embryo is hatched, (Pl. 23, fig. 4, 4a, 5, 6, 7, 8, 9, 10) the brain is far from having that long, slender, and flat shape which obtains in the adult (Pl. 25, fig. 13, fig. 13a). In addition to what has already been pointed out, (p. 575,) it may be added that the Schneiderian membrane is very thick, especially the wall (Pl. 23, fig. 4, fig. 11, w-c. 3, *b*, w-c. 11, *a*) facing the median line of the upper jaw. The channel (fig. 4, and w-c. 3, *a*) leading from the Schneiderian membrane gradually narrows, till, at the nostrils, it opens externally with a

[1] L. H. Bojanus, Anatome Testudinis Europeæ, etc., Vilnæ, 1819–1821. Compare his tab. 21, fig. 88, ii., ii.[1], ii.[2], with our Pl. 25, fig. 13a, and the explanation of his figure, p. 91, with ours.

small aperture. The walls of the olfactory bulb (fig. 4a, and w-c. 4, *d*) are very thick, especially at the constriction between the bulb itself and the hemispheres (*e*). This bulb is, moreover, larger and more distinguishable from the hemispheres than in the adult (Pl. 25, fig. 13, *ob*, fig. 13a, *ob*). The walls of the hemispheres (Pl. 23, fig. 4, fig. 4a, fig. 8, fig. 9, and w-c. 3, *e*, w-c. 4, *e*, w-c. 8, *a*, w-c. 9, *a*) are very thick, especially below and at the sides, where the corpora striata are forming (fig. 8, and w-c. 8, *a*, w-c. 9, *a*); so that, in the latter case, they equal the transverse diameter of the cavity (w-c. 8, *d*) which they inclose. The walls of the optic thalami also (fig. 4, fig. 4a, fig. 8, fig. 9, w-c. 3, *h*, w-c. 8, *f*, f^1) are very thick, fully as much so at the upper part as in the hemispheres, and leave only a very narrow cavity between them. At the inferior commissure (fig. 8, and w-c. 8, *g*) the wall is quite thin. The extreme lower end of this lobe is quite pointed; but there is yet no indication of a hypophysis, such as may be seen in the adult brain (Pl. 25, fig. 13a, *i*). The corpora quadrigemina (Pl. 23, fig. 4, fig. 4a, fig. 7, w-c. 3, *g*, *g'*, w-c. 4, *g*, w-c. 7, *a*, *a'*) have sunk so low that there is only a shallow space (fig. 7, and w-c. 7, *b*) between them and the floor of the aquæductus Sylvii. The walls (fig. 4, fig. 4a, fig. 7, and w-c. 3, *i*, w-c. 7, *c*, *c'*) of the aquæductus Sylvii are very thick, but do not equal, in this respect, those of the hemispheres and of the optic thalami. The view given in fig. 7, and w-c. 7, *c*, *c'* is that of a transverse section of the brain at a point, in the aquæductus Sylvii, which includes both the lateral and the anterior walls; hence their apparent, great thickness.

The aperture in the upper side of the medulla oblongata is nearly filled by the oblong mass of the arachnoid plexus (fig. 4, fig. 4a, fig. 6, and w-c. 3, *k'*, w-c. 4, k^1, w-c. 6, *b*, *b'*). At the edge of this aperture the wall terminates rather abruptly, (fig. 6, and w-c. 6, *c*,) except that at the posterior end, where the opposite walls meet, it comes to a sharp edge (fig. 4, fig. 4a, and w-c. 3, l^1, w-c. 4, l^1). The spinal marrow, although a closed tube with a very small channel, (fig. 5, and w-c. 5, *c*,) close up to the medulla oblongata, has yet a deep median dorsal sulcus, (fig. 5, and w-c. 5, *b*,) at least as far back as the base of the skull. As regards the spinal marrow, nothing more can be said now beyond what has already been stated above. A few additional remarks respecting its Histology may be found in the next section.

The Chorda dorsalis. Whatever further details are necessary in regard to this body may also be found in the section on Histology.

The Eye. The eye commences to form by a bulging (Pl. 12, fig. 9a, *k*) of the inferior and lateral sides of the optic lobe. When the head is seen from the side, the wall of this protuberance appears as a clear, bright, thick ring (Pl. 12, fig. 9, *k*). For a short time the hernia from the optic lobe continues to increase in prominence, and its wall grows thick, (Pl. 12, fig. 6, *k*,) without any change in its shape, except that its base becomes narrowed, so as considerably to lessen the channel (Pl. 21, fig. 28, *c*) of communication with the optic lobe. The pedicel does not meet the hernia at its centre, but at its lower side (Pl. 21, 28, *c*). At this stage the eyes may be described as pedicellated, asymmetrical, globular herniæ projecting from the lower side of the optic lobes of the brain. The musculo-cutaneous layer (Pl. 21, fig. 28, *b*) follows closely the constrictions of the hernia, and in this manner, embracing it closely, forms a sheath about it. Presently the wall at the lower side of the hernia begins to be depressed, as if it were pushed obliquely inward by some external force, thus producing a double-walled cup, attached by its side to a pedicel. By degrees the depression grows deeper and deeper, and the outer wall (Pl. 24, fig. 8, *k*) approaches the inner one (k') till they meet. A thickening of the musculo-cutaneous layer constantly follows the sinking wall, and at the time the two walls meet it forms a spheroidal body, the crystalline lens, (fig. 8, k^3,) moulded, as it were, in the cup of the eye. The depression at first extends for a short distance along the pedicel, but it is merely a narrow furrow, which has the appearance of being continuous with the channel (fig. 8, k^2) of the pedicel; however, it eventually disappears, as the inferior diverging borders of the cup approach each other.

The passage way along the pedicel, the optic nerve of the eye, has by this time become quite small (Pl. 24, fig. 7, k^2); and, in consequence of the bending of the pedicel in a downward direction, appears, further inward, totally below the eye, so as to allow a view into its cavity without looking through any portion of the cup. Soon the cup-shaped hernia, the retina of the eye, has approximated its interrupted inferior borders, till they are brought in contact, (Pl. 13, fig. 2 and 3,) and thus the capsule of the crystalline lens is completed. The point of junction of the borders just mentioned is not obliterated at once; but after a short time all trace of it seems to be gone. The borders of the sheath or orbit, formed by the musculo-cutaneous layer, have become contracted around the crystalline lens so as to overlap it, except at the fold on the side of the eye, where the optic nerve joins the retina. The fold subsequently becomes very conspicuous as a white band running from the lens toward the posterior side of the eye, in the midst of black pigment (Pl. 24, fig. 11). Soon after this, the eyes become circular, and a layer of black pigment develops upon the exterior surface of the retina, (Pl. 24, fig. 9a,) and therefore on the inner face of the orbit, the future membrana choroidea. The pigment does not develop over the fold which runs from the crystalline lens to the optic nerve, and consequently a white, broad streak is left on the lower side of the eye (Pl. 14, fig. 5). In a little older phase, what we have hitherto called the crystalline lens turns out to be not only that body, but its capsule also. The lens proper (Pl. 22, fig. 9, c^2) is formed by a hollowing of the solid mass which fills the depression in the retina, so as to leave a thin layer or outer wall attached to, and on a level with, the surface of the head, and a deeper layer or wall, from which a thick swelling (fig. 9, c^2) protrudes into the cavity (c^1) between these two walls. The outer wall (fig. 9, c) contains the elements of the conjunctiva and of the cornea, but we have not ascertained what becomes of the inner wall; it may turn out to be the iris.

The two walls of the retina (Pl. 22, fig. 9, d, d^1) have separated from each other; the outer one (d^1) remains closely pressed against its orbit, but the inner one (d) forms a partition behind the crystalline lens, (c^2,) and separates it from the cavity of the retina, which contains the vitreous humor. The fold of the retina, at the lower side of the eye, continues to grow narrower, but elongates as the eye increases in size, thus forming a narrow, white streak, (Pl. 24, fig. 11,) from the crystalline lens to the point of attachment of the optic nerve. The crystalline lens becomes a perfectly independent body, and develops its cells in a shape and with an arrangement peculiar to itself (Pl. 21, fig. 30, *a*, *b*). As yet there are no eyelids, (Pl. 15, fig. 13,) and the eye is unprotected, as in Fishes. In a little later phase, (Pl. 18a, fig. 3,) the skin adjacent to the eyes begins to encroach upon their anterior surface, in the form of a narrow rim. At this time, too, the white streak on the lower side of the eye has disappeared; at least, it cannot be seen externally, since several new coatings have been developed over it. The narrow rim around the eyes grows broader, (Pl. 18a, fig. 1,) and assumes more distinctly the appearance of an eyelid, and the eyes become less prominent. Soon the rim ceases to broaden at two opposite sides of the circle which it forms, but continues to increase in the intermediate space, (Pl. 25, fig. 10,) so as to produce a broad, oval opening between the approaching opposite edges, the upper half of the rim forming the superior eyelid, and the lower half the inferior eyelid. The eyelids continue broadening until they touch each other, and may be opened or shut at the pleasure of the embryo (Pl. 15, fig. 3). They never become agglutinated to each other, as happens among Birds and Mammals. The state of the membranes of the eye at this stage has already been sufficiently described (p. 570, Pl. 21, fig. 29, 31, 32–32d). Beyond this we have not had time to trace the development of the eye, and must leave the subject for future investigation.

At the time the Turtle was hatched, a very full examination of the structure of the eye was made, the results of which we will now proceed to give. On account of the softness of the different parts of the eye at that age, it was thought advisable to begin with some preliminary studies upon specimens hardened in alcohol. In this manner the topography and relations of the different membranes and layers can be made out quite easily, and, once familiar with the general structure of the eye of the Turtle, it is possible to dissect fresh specimens knowingly, and readily to detect any misplacements or distortions caused by the dissection. The outermost coat or covering of the eye is the conjunctiva (Pl. 22, fig. 8, a, a^1); that portion of it which lies exterior to the boundaries of the cornea (c^1) is a very thick, soft, and flabby membrane (a); but where it passes over the cornea it becomes very thin. Here it presses very closely upon the cornea, (c^1,) and is changed in its nature to a very tender and friable membrane, (a^1,) the conjunctiva of the cornea. The sclerotica (b, b, b^1, c^1) totally envelops the eye, except where the optic nerve (h^1) enters. In front of the eye it forms the cornea, (c^1,) a very tough, elastic, and transparent membrane, considerably thicker than the conjunctiva (a^1) which covers it. At the base of the iris, (e^1,) the cornea suddenly thickens, and, passing backward all over the eye, constitutes the sclerotic coat, (b, b^1,) which is a tough, dense, bluish membrane, much thicker than any other of the coats of the eye, and pressing pretty closely upon the choroidea (e); but it is not in actual contact with it, being separated from the same by a layer of black pigment (d). This pigment layer (d) extends from the edge of the cornea backward, over the whole eye, but disappears (d^1) at the point of entrance of the optic nerve (h^1). The choroidea (e, e^4)[1] is a very thin membrane, of uniform thickness throughout its whole extent, excepting where it passes along the optic nerve (h^1); there it thickens considerably (e^4). At its anterior border it begins again to thicken, just where the posterior edge (e^3) of the ciliary processes (e^2) terminates, and continues to increase in thickness until it reaches a point opposite the junction of the cornea (c^1) and sclerotica, (b,) where it thins out as it plunges into the aqueous humor. Here it constitutes the membrana iridis, (e^1,) a very spongy and loosely fibrous structure, resembling an irregular network. At this age, the iris (e^1) does not hang perpendicularly to the axis of the eye, but projects very obliquely forward, as it must necessarily do, because the crystalline lens presses upon it from behind, and forces it to slide over its convex surface, or rather that of the membrana pupillaris, (n,) when contracting and expanding. Even in the adult, this peculiarity (see fig. 7) obtains to a slight extent. The ciliary processes (e^2, e^3) extend from the free border of the iris (e^1) along its posterior surface, where it forms a thick posterior lining, and, thinning out rather abruptly about opposite the anterior edge (i^1) of the retina, continues for a short distance backward, and then terminates suddenly in a sharp edge, which may be easily separated from the choroidea, although

[1] In Pl. 22, fig. 8, the letter e^1 near h^1 should be e^4.

it is closely pressed upon it. That part of the ciliary processes (e^2) which covers the posterior surface of the iris (e^1). is very probably identical with that which is said to "exist over the posterior surface of the iris and the projecting ends of the ciliary processes"[1] in the human eye. Between the membrana iridis (fig. 8, e^1) and its posterior lining, (e^2,) there is a layer of black pigment, which extends backward till it reaches the posterior border (e^3) of the ciliary processes, where it becomes one with the pigment layer (*f*) which lines the choroidea proper (*e*). It is evident, that, whatever may be their connections in the higher animals, in the Turtle, even when full grown, the ciliary processes (see Pl. 22, fig. 7, e^2, e^3) are not an integral prolongation of the choroidea, but a separate layer, with a layer of pigment between the two membranes. The pigment layer (fig. 8, *f*) just mentioned as lining the choroidea, (*e*,) and its prolongation, the membrana iridis, (e^1,) constituting the so-called pigmentum nigrum, forks at the posterior edge (e^3) of the ciliary processes, and sends off a layer along the inner surface of the latter (e^2). The pigmentum nigrum is loosely coherent to the choroidea, yet presses very closely upon it. It disappears where the choroidea sheathes the optic nerve.

In specimens preserved in alcohol, this layer, the pigmentum nigrum, has a leaden aspect with a peculiar lustre, and clings to the membrana Jacobi (*g*) in preference to the choroidea, (*e*,) when the former is lifted off from the latter. The papillæ of the outer surface of the membrana Jacobi, plunging into the pigment layer, adhere to it much more firmly than the smooth surface of the choroidea. Next within the pigmentum nigrum (*f*) is the retina, (*g*, g^1, *h*,) which, in a section of its thickness, appears transversely striated over nearly its whole extent,[2] and seemingly divided into three layers. These apparent layers are the expressions of so many different strata of peculiar nervous cells, which will be described in detail hereafter; it may suffice here to say that they are not distinct layers. The outermost stratum (*g*) separates so easily from the inner one, that it has, until within a few years, been considered as a distinct membrane, under the name of "membrana Jacobi." In the Turtle, this peculiar stratum projects singly beyond the anterior edge (i^1) of the rest of the retina, and, pressing against that part of the pigmentum nigrum which covers the anterior extension of the ciliary processes, (e^2,) extends half-way to the edge of the iris (e^1). It is much thinner here than where it is connected with the inner strata of the retina; in the latter position it is quite thick, and uniform throughout (*g*). The exterior surface of the membrana Jacobi has a beautiful golden orange color, of

[1] Sharpey and Quain's Human Anatomy, London, 1848, vol. 2, p. 921.

[2] By mistake these striæ of the retina were not drawn perpendicular to its thickness, in front.

variable degrees of intensity. This color is situated totally within the large mesoblasts of the columnar cells which compose the stratum (see Pl. 21, fig. 33, *h*, *i*, fig. 33a, *a*, *b*, *c*). The combined strata of the retina (Pl. 22, fig. 8, *h*) with the membrana Jacobi (*g*) have a uniform thickness throughout, except at the anterior border, where they suddenly thin out and come to a sharp terminating edge, (i^1,) at a short distance behind the base of the iris. Opposite the entrance of the optic nerve, (h^1,) the retina preserves the same uniformity as elsewhere, nor do there appear to be any nervous fibres prolonged through it from the optic nerve; but this point wants further special investigation. The optic nerve, (h^1,) as well as the whole retina, is hardly consistent enough to hold together, when separated from the surrounding envelopes. Just within the retina, there is a very thin, striated layer, (*i*,) composed of wavy fibres, which apparently radiate from the optic nerve (h^1) in every direction, and extend to the anterior edge (i^1) of the retina.

In another place it will be shown in detail, that these fibres are not prolongations from the optic nerve, but belong to the inner layer of nervous cells, of which they are tail-like prolongations (see Pl. 21, fig. 33, *b*). Next within the layer of wavy fibres (Pl. 22, fig. 8, *i*) is the membrana hyaloidea, (*k*, k^1,) forming a closed sac, and lining the whole internal surface of the retina and the back of the crystalline lens (*l*). This membrane lies close against the retina over its whole extent, even to within a very short distance of the anterior edge of the membrana Jacobi, (g^1,) where it folds backward and passes (k^1) close behind the crystalline lens, (*l*,) where it may be traced as readily as at any other part. The soft, thick, and tender nature of this membrane readily distinguishes it from the excessively thin, tough, glassy, glittering, and elastic triple membrane which forms the capsule (*m*) of the crystalline lens. The three membranes composing the capsule (*m*) of the crystalline lens adhere very closely to each other, so that it is very difficult to separate them. At the spot where the membrana hyaloidea comes in contact with the crystalline lens, the membrane of the capsule sends off a layer forward and centrifugally, which joins the hyaloidea as far as its first bend, (k^2,) and thence, turning suddenly upon itself, passes forward and centripetally before the edge (n^1) of the membrana pupillaris, (*n*,) by which it is closely overlapped, and to which it adheres very tenaciously, and terminates a little behind the free edge of the iris. This portion of the membrane of the capsule clings so closely to the hyaloidea, especially at the angle (k^2) where it reverts to pass before the membrana pupillaris, that, were it not for the great difference in structure between the two, as we have pointed out above, it might easily be mistaken for a continuation of the membrana hyaloidea, as it has been asserted to be, in the eye of Mammalia.

The crystalline lens, (*l*,) when seen in profile through a line perpendicular to the axis of the eye, has a symmetrical, oval outline, the anterior and posterior surface being of equal curvatures. The membrana pupillaris (n, n^1) presses pretty closely upon the anterior surface of the crystalline lens, (l,) being kept in its place by its attachment (at n^1) to the free portion of the capsule of the lens, and extends behind the free edge of the iris nearly half-way (n^1) to its base. It is nearly as thick as the conjunctiva, (a^1,) and has something of the same brittle, soft, inelastic, dense nature. By these properties it is easily distinguished from any other membrane near it. Under the influence of alcohol it retains its shape and smoothness, whilst the membrana hyaloidea becomes very much shrunk and shrivelled. The membrana pupillaris does not disappear in the adult, and very probably remains through life, since it was found in the eye of a specimen of Trachemys scabra which was about twenty years old. In this case the membrane was double, (Pl. 22, fig. 7, n, n^1,) and very thick. The vitreous humor, at the time the Turtle is hatched, is so soft and so little consistent that it may be poured out of the eye almost as easily as if it were water.

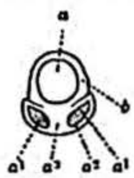
The Ear. The earliest indications of the presence of the ears that have been observed are two cup-shaped depressions, (Pl. 12, fig. 8, 9, 9a, l,) one on each side of the base of the head, in the musculo-cutaneous layer, and a narrow band or projection running from the median line of the under-side of the medulla oblongata to the bottom of each cup. The cup, or meatus auditorius, gradually broadens at its mouth, (Pl. 12, fig. 6, l,) and grows narrow at the bottom (Pl. 18a, fig. 13, l) till it assumes a very broad trumpet shape, (Pl. 24, fig. 7, l,) which it retains, with slight modifications, for the rest of its life. Eventually the mouth of the meatus becomes covered by a thin, transparent membrane, (Pl. 18a, fig. 1,) the membrana tympani, which finally assumes an opaque and dense nature in the adult, and is covered by the still denser and tough epidermis. The narrow band, the auditory nerve, (Pl. 12, fig. 9a, p. 548,) which passes from the brain to the meatus, becomes in the end very broad, (Pl. 23, fig. 1, l, fig. 1a, l, fig. 2, l,) and is situated higher up on the side of the medulla oblongata; and, finally, by the time the Turtle is hatched, its end expands into a large, convoluted, hollow hernia, (Pl. 23, fig 7, and wood-cut 7, c'', p. 577) which fills a considerable portion of the vestibule. Each convolution, of which there are three, is very broad, and opens widely into the main cavity, the alveus of the hernia. The pia mater extends as a sheath (w-c. 7, f) from the brain all over the auditory nerve, and its expansion (w-c. 7, f') in the vestibulum. The vestibule (w-c. 6, c) is very high, reaching from below the level of the medulla oblongata (w-c. 6, c, c') to a point as high as the posterior end (w-c. 6, a'') of the corpora quadrigemina; and antero-posteriorly, from the anterior wall of the fourth ventricle (w-c. 3, i, w-c. 7, c, c') backward to the posterior end (w-c. 6, a) of the cerebellum.

The ante-vestibulum, or the cavity of the tympanum, (fig. 6, fig. 7, and w-c. 6, *e′*, w-c. 7, *i*,) which contains the bone, the stapes of the ear, is very large, and is divided into two compartments, one nearly globular, the mastoid sinus, (fig. 6, and w-c. 6, *e′*,) opening forward into a larger one, the true tympanic cavity, (fig. 7, and w-c. 7, *i*,) which is very high, and narrower than the other. The ante-vestibulum extends much further, both before and behind, than the vestibulum. The stapes, the only bone of the ear that the Turtle possesses, is a short and thick cartilaginous cylinder, (fig. 7, and w-c. 7, *i*,) with very broad exterior and interior ends.

The Nostrils. Whatever may be necessary to the understanding of the formation and development of the nostrils has already been mentioned above. (See p. 555, Pl. 24, fig. 12, *v*, p. 559; Pl. 18a, fig. 9, *v*, p. 562; Pl. 24, fig. 11, *v*.)

The Vertebral Column. The process of the origin of the vertebral layer, and the mode of formation of the vertebræ from this layer, have been quite fully described, when treating of the earlier stages of the embryo as a whole. (See p. 543 and 545.) There are a few points, however, which need separate notice, in regard to the special growth of the vertebræ. After the vertebræ are clearly defined, (Pl. 12, fig. 3, 3a, 3b,) the centre of each changes in its appearance, and becomes more transparent than the periphery. Upon investigating this peculiarity in a little later stage, (fig. 9, *f*, fig. 9a, *f*,) it was found that each vertebra, or rather each half vertebra, is composed of cylindrical, wedge-shaped cells, forming a very thick wall, (Pl. 19, fig. 3,) inclosing a large, clear space. By following the development of the vertebræ through their progressive stages, we find that this clear space finally loses its sharply marked boundaries, and gradually blends with the surrounding wall (Pl. 24, fig. 14, *f*). The centre remains for a while transparent, probably in a fluid state; but between this centre and the walls a more solid substance seems to be filling in. What the nature of this substance is, was not ascertained. Finally, the whole half vertebra appears, under a low magnifying power, homogeneous throughout (Pl. 24, fig. 9, *f*). In the latest stages, at the time of hatching, when the vertebræ have become partially ossified at the periphery, (Pl. 22, fig. 3, and w-c. 12, a^2,) the centre (a^1) of each half is again very clear, and is composed of large cartilage cells, (Pl. 22, fig. 4,) identical with those found in the centre of the ribs (see Pl. 22, fig. 1, *a*, fig. 2, *a*). How these cartilage cells are developed in this instance has not been ascertained, nor have we any data upon which a supposition can be founded. The chorda dorsalis has disappeared at this age, and the two halves of the vertebra have united at the middle line, (w-c. 12, a^3,) so as to leave no sign of their point of junction. The vertebræ may be traced to the very tip of the tail; and their number, fifty-five, equals that found in the adults.

Wood-cut 12.



The Skull. It is not till much later than the appearance of the vertebræ that the cranial portion of the vertebral column makes its appearance. The earliest period at which we have noticed it was after it had risen from below, so as to envelope the whole brain in front of the cerebellum, (Pl. 24, fig. 7, e^2,) and had gained considerable thickness, almost twice as great as the skin just exterior to it. It rises gradually at the posterior part, and grows proportionally thinner, except at its base, (Pl. 23, fig. 3, *1*,) where it becomes very thick. At this point it is merely cartilaginous, and extends in a uniform layer from the nose (fig. 3, *4*) to the posterior opening at its base, (fig. 3, *1*,) including the elements of the vomer, (*5*,) which underlie the Schneiderian membrane (c') and the space between the eyes, the ethmoid, (*3*,) the sphenoid, (*6*,) the basal occipital, (*2*,) the occipital crest, (*1*,) and several other bones, not indicated in the figures. The supermaxillary or upper jaw bone (fig. 3, *8*) forms a separate cartilaginous layer. At the time the Turtle is hatched, the different bones of the head are generally marked out, but in very different degrees of ossification. The os incisivum, (Pl. 23, fig. 4, and w-c. 3, *l*,) or intermaxillary bone, although as yet very spongy, is the most ossified, and is probably the one most needed of any for the purposes of feeding. The upper maxillary, (fig. 11, and w-c. 11, d',) the ethmoid, (fig. 4, fig. 11, and w-c. 3, n'', w-c. 11, *d*,) and the frontal bones (fig. 4, and w-c. 3, *n*, fig. 10, and w-c. 10, *f*) are hardly less ossified than the mandibles. The parietal (fig. 8, and w-c. 8, *h*) and the sphenoid bones (fig. 8, and w-c. 8, *i*) come next in hardness. The crest of the occiput (fig. 4, fig. 5, and w-c. 3, *n*, n', w-c. 5, *m*, m') has only an external layer (w-c. 3, n', w-c. 5, m') ossified, the rest is cartilaginous; the basilar portion (fig. 4, and w-c. 3, *r*) of this bone begins to be hardened internally. The same may be said of the sphenoid bone (fig. 4, fig. 8, w-c. 3, r', w-c. 8, *i*). The other bones of the head are, as a general thing, merely cartilaginous. The basilar part (fig. 4, and w-c. 3, *r*) of the occipital bone does not trend in the same line with the sphenoid, (r',) but is elevated to an angle of at least thirty degrees above it. In the adult, these two bones trend in the same line.

The Shield.[1] Very few investigations have been made respecting the development of the different elements which compose the shield.[2] The manner in which the roof-like dorsal shield originates has already been described, (p. 562, Pl. 15, fig. 13,) and the changes in form through which it passes have been pointed out. We are not prepared to say any thing more in respect to its internal metamorphoses, until the time when the young Turtle is hatched. At that time the shield

[1] Comp. Part II., Chap. 1, Sect. 4, p. 255, and Sect. 5, p. 263–265.

[2] For more details, see Rathke, Entwickelung der Schildkröten, p. 84, 101, 105, and 177.

consists of the vertebral column already described, the fibrous corium, (Pl. 9e, fig. 12, *c*,) and the ribs (*a*, *b*) imbedded in the latter. The ribs do not touch each other laterally, as in the adults of many genera, but their margins (Pl. 9e, fig. 12, *b*) are flattened, and run out into a thin edge. At the surface of the ribs, the passage is so gradual from the fibrous bony layer (Pl. 22, fig. 1, *b*, *c*, *d*, *e*, *f*, fig. 2, *b*, *c*, *d*, *e*, *f*) into the fibrous corium, (fig. 1, *g*, g^1, *h*, h^1, fig. 2, *h*,) that it is impossible to distinguish the one from the other. In fact, since the ribs are developed from what was once a uniform layer of corium throughout the whole extent of the shield, it is not at all to be expected that the line of demarcation should be very definite at this age. The true cartilagino-osseous matrix of the ribs is in the interior of each rib (Pl. 9e, fig. 12, *a*, *a′*; Pl. 22, fig. 1, *a*, a^1, a^2, a^3, fig. 2, *a*, a^1, a^2, a^3).

The Limbs. The changes through which the limbs pass, as far as their external configuration is concerned, have been sufficiently described in the last section. At first they are lateral protrusions (Pl. 24, fig. 14, w^1, p. 555) of the musculo-cutaneous layer from the sides of the body, and are composed of a solid mass of cells, identical with each other throughout the whole limb. The bone, or rather the matrix of the bone, is formed by a certain portion of the cells in the axis of the limbs becoming differentiated from the others, by increasing in size and assuming a less elongated shape, (Pl. 21, fig. 22, 22a, 24,) and at the same time separating from each other. This arrangement produces a different effect upon the light from that of the cells in the surrounding parts, so that the position of each bone-matrix may be recognized without much trouble (Pl. 25, fig. 11). The matrices are not sharply defined, because the passage from the elongated cells of the unossifying portion to the broad cartilage cells of the matrix is not sudden, but gradual. Later, however, the bone matrix becomes more definite in outline, (Pl. 21, fig. 21; Pl. 25, fig. 12, *b*, *c*, *d*,) and differs very much in appearance from the surrounding portion of the limb (Pl. 21, fig. 20, *b*, *b′*; Pl. 25, fig. 12, *a*). About the time of hatching, the bones are all well developed, and have in a great measure the characteristic shape of those of the adult, but the ossification is only external, the central part of the bones being occupied by almost pure cartilage (Pl. 22, fig. 5, 6, 6a, 6b). The bones of the feet are the most ossified, especially the terminal ones; and not only is the fibrous layer hardened, but also a considerable thickness of the cartilaginous basis contains lime. The femur comes next in amount of ossification, but this occurs only along the cylinder, and not at all on the ends. The scapula, and its process, the acromion, are but a little less ossified than the last. The other bones have a very thin external fibrous ossified layer, the rest of each bone being highly cartilaginous.

The Muscles. During our investigation of the development of the Turtles, our attention has chiefly been devoted to those points which are less fully illustrated in Rathke's monograph. The minuteness with which he has described the muscular development of a number of young Testudinata belonging to several distinct families[1] has induced us to enter into fewer details upon this point, especially since the muscles of the adults are fully described in a preceding part of this work.[2] On that account, we have taken more particularly into consideration the Histology of this system, for which we refer to the next section. (See also p. 592, Pl. 19, fig. 25.)

The Heart. The heart, and in fact the whole circulatory system, is a development of the dorsal surface of the intestino-subsidiary layer into a vast network of anastomozing channels, through which the blood runs in certain determined directions. It is within the boundaries of the central propeller of the circulation that the blood first makes its appearance, surging backward and forward. At first, circulation is a mere tossing of elementary cells and albuminous fluid from one side to the other of the simple saccular heart (p. 547; Pl. 12, fig. 7, *h*). After the vertebral layer (Pl. 9e, fig. 4, f^1, fig. 4a, f^1, f^5, fig. 4b, f^1) has divided off from the subsidiary layer, (fig. 4, o^1, *n*, fig. 4a, o^1, *n*, fig. 4b, o^1,) the latter becomes separated from the former to a considerable extent, so as to leave a cavity (Pl. 9d, fig. 1, *h*, j^2; Pl. 9e, fig. 5, j^2) of variable depth between the two. This cavity is deepest along the median line of the body, and grows shallow on each side till its upper and lower walls meet along the sides of the embryo. At the anterior part of the body, the largest and deepest portion (Pl. 9d, fig. 1, *h*) of the cavity is nearly altogether shut off from the rest; this is the heart. As yet there is no circulation in it, there being no walls proper; in the beginning it merely marks its position, just in the same way that the primitive furrow indicates the site of the spinal marrow. However, in order to avoid confusion, we will at once designate it as the heart, and speak of it as such during its formation, as well as afterwards. In the beginning, the heart lies at the inner angle of the curve of the head, so that it is partly in the dorsal and partly in the ventral region, and is essentially more anterior than the brain (fig. 1, e^1, e^0). This latter feature would be more readily perceived if the embryo were represented in a straightened position.

On account of the absence of a circulating fluid of any consistency, the heart is not perceptible in a general view of the whole animal. It requires a longitudinal section (Pl. 9d, fig. 1) of the embryo, in order to lay it open to view. On this account it is not seen in several of our figures representing external views of some older stages, (Pl. 12, fig. 3, 3a, 4,) where the anterior bend (fig. 3, a^6, fig. 3a, a^6) of the body has receded toward the abdominal

[1] Rathke, Entwickelung der Schildkröten, p. 154.

[2] Comp. Part II., Chap. 1, Sect. 7, p. 270.

region. Soon, however, the subsidiary layer forms a wall around the cavity of the heart, partly by a direct hollowing in its own thickness, thus constituting the lower wall, as we may see by the thinness of the layer at this spot (Pl. 12, fig. 7, *h*, *i*); and partly by elevating the edges of the channel and closing them over, so as to form an arch, or superior wall. Thus, in the beginning the heart is a simple, straight tube, (fig. 7, *h*,) trending in the same direction with the axis of the body. The posterior end of the heart becomes connected, or rather continuous, with a transverse channel (fig. 7, *i*) which is formed in the same way, and the anterior end with two other channels (fig. 7, *j*) of similar origin, which pass, one on the right, and one on the left, up along the sides of the head. Presently the heart bends upon itself at two different points; at one point, behind, it curves to one side, (Pl. 12, fig. 10, *h*,) and at the other, before, downward, as it joins the branchial aortæ (fig. 10, *j*). About this time, too, it begins to swell in its middle region, (fig. 6, *h*,) and curves outward; moreover, it has become separated from the subsidiary layer by a kind of longitudinal constriction; but the rest of the channels of circulation remain as they originated. These curves grow stronger until there are three quite distinct chambers, one in front of the anterior curve, the aortic bulb (Pl. 18a, fig. 13, h^1); another, the ventricle, (h^4,) just behind, trending in an obliquely transverse and backward direction toward the right side; and the last, the auricle, (h^3,) running from right to left and obliquely forward and downward. The communications between these three cavities, and also between the last and the vena afferens, (*i*,) are still very broad. The wall of these cavities, especially that of the auricle, (h^3) has become very thick. At this time there is a complete system of efferent and afferent vessels throughout the body, so that the blood passes in a perfect circle from and to the heart.

Another chamber is subsequently formed, by a median transverse constriction of the auricle, making in all three distinct compartments, (Pl. 13, fig. 2,) communicating with one another by narrow channels in the heart proper, and a fourth, just in front of it, the aortic bulb. The relative positions of the three chambers become changed at this time: the anterior one, the ventricle, (Pl. 18a, fig. 11, h^4, fig. 12, h^4; Pl. 24, fig. 7, h^4,) falls to a lower level, which is the same, or nearly so, with that of the middle chamber, the left auricle (Pl. 18a, fig. 11, h^3, fig. 12, h^3; Pl. 24, fig. 7, h^3). The inversion of the heart goes on till the relative positions of the auricles and ventricle are totally opposite to what they were at first; the auricles (Pl. 24, fig. 9, h^3) being situated next to the back and directly above the ventricle, (fig. 9, h^4, fig. 9a, h^4,) which occupies the ventral region, to the total exclusion of the other chambers of the heart. This is the position which the heart holds in the adult. The ventricle, (fig. 9, h^4, fig. 9a, h^4,) at the same time that it sinks toward the ventral side, increases very much in size, so as to equal in bulk both auricles, and, moreover, undergoes a remarkable internal change, which consists in the formation of a thick network of high and narrow semi-partitions on its inner surface, occupying nearly the whole cavity of the chamber.

The figures of the next stage, (Pl. 18a, fig. 8, 9, 10,) which, by the way, have already been sufficiently described, (p. 559,) apparently contradict the statements just made in regard to the relative size of the chambers of the heart; but this is readily explained by the fact, that, during the contraction of the ventricle, (fig. 8, h^4, fig. 10, h^4,) the auricles (fig. 8, h^3, fig. 10, h^3) become very much distended and enlarged. Now that the heart has assumed a position which it ever after holds, the only further changes which it undergoes relate to the comparative size of the different chambers, the narrowing of their channels of communication, and the formation of valves at the mouths of these channels. The ventricle (Pl. 24, fig. 10, 10a, 10b, h^4) finally becomes twice as large as the two auricles combined (fig. 10, 10a, 10b, h^3); the meshwork of semi-partitions disappears, and is replaced by a very thick wall, (fig. 10b, h^4,) traversed by irregular canals. It can hardly be doubted, from the appearance of the wall of the ventricle, that the semi-partitions have become obscured simply by thickening until they touch each other, except at a few points, which correspond to the irregular canals which pass from the internal nearly to the external surface of the wall.

The manner in which the valves (Pl. 24, fig. 10b, *vl*) are formed has not been ascertained by tracing their development; but, as they are simple projections from the edge of the opening (fig. 10b, *vo*) of the passages from the auricles (h^3, h^3) into the ventricle, (h^4,) it is very probable that they originate by a gradual elevation of this edge until it constitutes a lappet, or fold, sufficiently broad to extend across the whole diameter of the opening. These two valves are properly within the ventricle, (fig. 10b, h^4,) and, when inactive, hang loosely into its cavity; but upon the contraction of this chamber they are pressed upon by the blood, and apply themselves over the apertures to which they respectively belong, and prevent the regurgitation of blood into the auricles (fig. 10b, h^3, h^3). The valves at the opening of the venous sinus (fig. 10a, *vs*) are mere protrusions of the lips of a transverse fissure into the right auricle. The passage of the blood through the heart at this phase is very irregular; first entering at the venous sinus, (fig. 10a, *vs*,) it passes into the right auricle, and thence, in part, directly into the ventricle, (h^4,) and in part into the left auricle, and from that into the ventricle, (h^4,) thence again to pass out through the right[1] and left (fig. 10,

[1] The right aorta, unfortunately left by mistake unlettered in the figures, doubles at a little distance from its point of origin, and may be recognized here as the shortest vessel in the figure.

pa, 10a, *pa*, 10b, *pa*) aortæ and the pulmonary artery (fig. 10, 10a, 10b, h^1, h^2). Our investigations in regard to the relations of the heart to the different vessels which pass to and from it are quite defective, and, like other points in the development of the organs, must be left for future research.

The Bloodvessels. All the principal bloodvessels originate, like the heart, as channels, hollowed in the superior thickness of the subsidiary layer. We have already (p. 545 and 594; Pl. 9d, fig. 1, *h*, j^2; Pl. 9e, fig. 5, j^2) pointed to the fact, that the subsidiary layer becomes more or less separated from the layers above it; but, with the exception of the tracks along which vessels are formed, this gap is afterwards filled up again. After the initiatory steps are taken to form the heart, the anterior pair of the branchial aortæ (Pl. 12, fig. 7, *j*) are developed: they appear as channels running obliquely forward and upward, one on each side of the head, from a common point of origin, the heart, (*h*,) toward the dorsal region (p. 547). At the same time, the branches (fig. 7, *i*, *i*) of the afferent vessel, the omphalo-meseraic vein, commence as nearly transverse channels opening into the posterior end of the heart (*h*). These transverse channels (*i*, *i*) are exactly in that bend of the subsidiary layer which forms the anterior edge of the abdominal cavity. Exterior to the body, the omphalo-meseraic vessel first appears as a broad and thick band, (i^1, i^1,) which subsequently becomes hollow, and constitutes the vena terminalis.

At the time the branchial fissures (Pl. 12, fig. 8, *m*, fig. 9, *m*) are formed, the three other branchial aortæ (Pl. 18a, fig. 11, h^3, and note 2, p. 551) are developed between, and run parallel with them. A little later, the branchial aortæ empty into the two branches of the dorsal artery (Pl. 18a, fig. 11, j^2, also fig. 7, *j*). Beyond this we have nothing more to say in regard to the branchial aortæ themselves besides what has already been stated in the section on the general development of the embryo.

The aorta dorsalis, or descendens, originates as a forked vessel, one limb of the fork running along the right side, (Pl. 18a, fig. 11, *j*, j^2,) and one along the left, (Pl. 18, fig. 7,) of the dorsal region, just behind the head, and uniting into one median channel (Pl. 9e, fig. 7, j^2; Pl. 18, fig. 7) at a short distance behind the heart. From this point it runs singly along the axis of the body to its posterior extremity; and finally, when the tail is developed, to the end of that organ (Pl. 13, fig. 2, w-c. 1, j^2, p. 553). The anterior ends of the two branches of the fork of this vessel run forward into the head, (Pl. 18a, fig. 11, *j*,) and eventually branch there very extensively (Pl. 13, fig. 2). Soon after the forming of the aorta, lateral branches (Pl. 18, fig. 5, 7) run out from its right and left sides and pass into the vascular area, and its posterior end forks, and joins the two lateral abdominal veins. Presently the allantoidian arteries (Pl. 13, fig. 2; w-c. 1, n^0, p. 553) also arise from its posterior end. After a while its abdominal portion has less numerous outlets, (Pl. 13, fig. 3, *q*,) all of which finally merge into one, the omphalo-meseraic artery (Pl. 18a, fig. 14, j^4, j^5). This is very easily understood, if the very loose connection of the cells of the subsidiary layer is borne in mind; the channels for the blood, having no wall, readily change their course, and merge into each other, and finally form one large stream for the exit of the arterial blood. Around this single, large channel a distinct wall is eventually formed.

In the beginning, the omphalo-meseraic artery, or rather arteries, are mere lateral diverticula of the dorsal artery, (Pl. 18, fig. 7,) but do not originate from it as a starting point. It is rather singular, but nevertheless true, that the first indications of this system of vessels appear at the extreme edge of the subsidiary layer, in the form of a thickening (Pl. 9d, fig. 1, i^1, i^1; Pl. 9e, fig. 5, i^1, i^1) of the periphery of the latter. This thick border goes on broadening for a while, till it becomes quite conspicuous (Pl. 12, fig. 7, i^1) as a well defined ring surrounding a broad space bordering on the abdominal region of the embryo. One portion of it, that nearest to the head, curves inward, and lies in close connection with the transverse vessel (*i*) which leads into the posterior end of the heart. For a short time, this ring gradually expands, and incloses a large area, (Pl. 14, fig. 12,) without exhibiting any other change; but finally little, dark, hollow spaces appear, (Pl. 14, fig. 11,) arranged in one, two, or three irregular rows or concentric circles. These are collectively called the vena terminalis; but it is impossible at this stage to separate them from the arterial vessels which commingle with them here, so that it is quite proper to say that the omphalo-meseraic arteries, and the veins also, originate first at the circumference of the vascular area.

Almost synchronically with these circular vessels the true omphalo-meseraic arteries appear as dark streaks, more or less continuous, converging from the vena terminalis toward the body. Presently both the interrupted channels of the vena terminalis and the external omphalo-meseraic system anastomoze completely with each other, (Pl. 18, fig. 5, 7,) and form continuous channels for the circulation of the blood. The channels are very irregular at diverse points, (Pl. 18, fig. 6,) both as regards breadth and depth, some appearing very shallow, as if just forming. In the latter case, there is no mistaking that they are hollows in the upper surface of the subsidiary layer. It is difficult to say at what stage walls are formed around these channels; but certainly not till some time after they originate (Pl. 14, fig. 5; Pl. 17, fig. 5). Finally, however, they are endowed with a very thin wall (Pl. 18, fig. 2). At the first glance it would appear as if the walls of the vessels must be constantly resorbed, and new ones formed as the vascular area enlarges; but we do not believe that this occurs extensively, nor that the vascular area expands beyond a certain limit. By the time these walls are formed, the yolk begins sensibly to diminish in bulk, and the vascular area gradually folds around this shrinking mass; thus essentially covering a greater proportion of its circumference, but by no means a wider extent of actual surface. Toward the end of the period of incubation it even diminishes in area, till finally it disappears altogether, within a few months after the Turtle is hatched.

A peculiarity, which, until quite a late period, distinguishes the omphalo-meseraic arteries from the veins, is that they run, even to their outermost extremities, (Pl. 17, fig. 6, fig. 7,) in a very shallow stratum, the subsidiary layer, without plunging into the yolk mass beneath. Finally, however, they extend into the mass of the yolk, (Pl. 17, fig. 1,) and anastomoze with the branches of the omphalo-venous system (Pl. 18, fig. 4). The irregularity of development of the vascular area is particularly noticeable among the other inequalities of the development of the organs. Pl. 13, fig. 11, Pl. 14, fig. 6, 9, 11 are all drawn, on the 10th and 11th of July, from eggs laid by the same Turtle, on the 18th of June; and yet, in Pl. 14, fig. 11 the vena terminalis is partially formed, in Pl. 13, fig. 11 it is a little more advanced, in Pl. 14, fig. 9 it is complete, and the vascular area covered with bloodvessels; and in Pl. 14, fig. 6 the omphalo-meseraic arteries are still more numerous. Another, laid on the 13th of June, (fig. 8,) is not so far advanced as one laid on the 18th of June, (fig. 6,) whilst the latter is less advanced than one (fig. 7) laid on the 23d of June. Compare also Pl. 13, fig. 4 and 5 with fig. 6, 7, 8, 9, all of which were laid on the 12th of June, and opened July 11th. Within the body, the changes in the omphalo-meseraic arteries are very simple. At first they are numerous, (Pl. 18, fig. 7,) and spring from along the whole length of the dorsal artery; but after a while they become concentrated within a certain area, (Pl. 13, fig. 3, *q*,) midway between the head and tail, and finally merge into a single thick vessel, (Pl. 18a, fig. 14, j^4,) which branches beyond the body as it passes into the vascular area. It soon begins to elongate, at the same time lessening in diameter, (Pl. 18a, fig. 8, j^5 to j^4, fig. 9, j^4,) and passes down between the anterior (fig. 8, n', fig. 9, n') and posterior (fig. 8, n^1, fig. 9, n^1) limbs of the curve of the intestine, where the latter protrudes beyond the body, in the shape of a U; it then forks, one branch passing on the right, and the other on the left, of the curve. Each branch of the fork divides again, almost as soon as it leaves the main vessel, and these branches give rise to others, and these to still others, and so on until they become very numerous. At last, the efferent artery gives off branches, within the body, which ramify extensively over the intestine (Pl. 17, fig. 1).

The vena terminalis, as has already been shown, develops first in its peripheric portions, and finally joins the vena afferens, which at the time is a transverse and very short vessel (see Pl. 12, fig. 7, *i*). The vena terminalis gradually embraces a larger area, up to a certain extent, (Pl. 13, fig. 2, fig. 12,) and then begins to sink below the surface of the yolk, (Pl. 14, fig. 2, 2a, r^1, r^1,) following the vena afferens, until, finally, it is lost in the maze of anastomozing vessels which empty into the vena afferens (Pl. 9c, fig. 3). At the same time, however, the vascular area continues to expand superficially, until, at last, it embraces the whole yolk mass. At first, the vena afferens apparently lies within the body of the embryo (Pl. 12, fig. 7, *i*); but it is really as much without as within, being at the bend (corresponding to the point a^6 in fig. 1, Pl. 9d) where the vascular area joins the body. This transverse vessel (Pl. 12, fig. 7, *i*, *i*) corresponds to the fork of the vein, there being as yet no intermediate portion between it and the heart (*h*). Soon, however, it assumes a furcate shape, (Pl. 12, fig. 10, *i*,) and a little later it retreats from the heart, becoming still more decidedly forked, (Pl. 18a, fig. 13, *i*, *i*,) and empties into a short but distinctly developed single vein, the vena afferens (fig. 13, *i*′).[1] The vena afferens elongates rapidly, and its fork retreats still further, till it comes in a line with the vena terminalis (Pl. 18, fig. 7). After a short time it begins to sink into the yolk, (Pl. 14, fig. 2, 2a, *r*,) and then branches very extensively, until in time it passes directly (Pl. 16, fig. 2a, *r*′, fig. 2b, *r*′) through the vitelline mass, and the latter becomes filled by anastomozing vessels, (Pl. 9c, fig. 3; Pl. 17, fig. 3, fig. 7,) constituting, not as before, a superficial vascular area, but a globose, vascular plexus, an extension of the vascular area, throughout the whole breadth and depth of the yolk.[2]

The Abdominal Vein. (See p. 552, and Pl. 18, fig. 7, etc.)

The Allantoidian Artery. (See p. 553, Pl. 13, fig. 2, and w-c. 1, n^6, etc.)

The Allantoidian Vein. (See p. 554, Pl. 13, fig. 2, and w-c. 1, i^2, etc.)

The Branchial Fissures. (See p. 548, and Pl. 12, fig. 8, *m*, 9, *m*, etc.)

The Intestine. The digestive system begins rather late to develop, but its foundation is laid by the subsidiary layer (Pl. 9d, fig. 1, *n*) quite early, in the form of two blind sacs, one just behind the heart, (*h*,) and the other, at the opposite end of the body, immediately inclosed by the incurved tail. As the abdominal aperture grows narrower, these sacs consequently increase in length, without undergoing any other change for some time. Of the two, the posterior one first loses its simplicity by the development of a hernia, the allantois, (Pl. 13, fig.

[1] The letter *i*, nearest to the letter h^3 in fig. 13, Pl. 18a, should be *i*′.

[2] For further details upon this point, see p. 527, 528, and 529.

2, w-c. 1, n^6, p. 553,) from its lower side; the remainder constituting the true intestine, called the thick intestine, in this region of the body. Not much later, the anterior blind sac becomes changed, by the folding together of the two opposite halves of its superior arch, to form a pendent double curtain, or support of the intestine, the mesenterium, and, by the separation of a portion of its lower side, to form the windpipe (Pl. 24, fig. 1, *1‴*, *2‴*) and the lungs (*1*, *2*). The greater portion, (*1′*, *1″*, *2′*, *2″*,) however, remains, and develops into a double-walled channel, the œsophagus (*1″*, *2″*) and the stomach (*1′*, *2′*). The inner wall (*2′*, *2″*, and fig. 1a, *2′ 2″*) constitutes the epithelial layer, otherwise called the mucous membrane, and is continuous with the inner wall (fig. 1, *2*, *2‴*, fig. 1a, *2*, *2‴*) of the lungs and windpipe. Exterior to the embryo, the continuation of the outer wall (fig. 1, *1′*, *1″*) of the intestino-subsidiary layer is very thin, and the inner wall (fig. 1, *2′*, *2″*) loses its compactness, and becomes continuous with a rather thick layer of large hyaline cells, (see Pl. 17, fig. 3, and p. 566,) which underlie the vascular area. The double pendent curtain, or mesenterium, soon forms along the abdominal region, still retaining its thick, double walls (Pl. 9e, fig. 8, n^8, fig. 8a, n^8) after the intestine (fig. 8, n^2; Pl. 18a, fig. 7a, n^1, fig. 8, n^1, n', n^4, fig. 9, n^1, n', n^2) has become so long as to protrude through the abdominal opening.

The Glands of the Stomach. (See p. 571, and Pl. 21, fig. 14–16, etc.)
The Lungs. (See p. 555, and 556, and Pl. 24, fig. 1, 1a, etc.)
The Liver. (See p. 555 and 556, and Pl. 24, fig. 9, *r*, fig. 9a, *r*, etc.)
The Gall Bladder. (See p. 563, and Pl. 18a, fig. 5, *u*, etc.)
The Wolffian Bodies. (See p. 552, and 560, and Pl. 18a, fig. 8, etc.)
The Kidneys. (See p. 566, and Pl. 25, fig. 4, *b*, and w-c. 2, *b*, etc.)
The Ovaries and Spermaries. (See p. 567, and w-c. 2, *n*, etc.)
The Urinary Bladder. (See p. 572, and Pl. 25, fig. 1, n^6, etc.)
The Allantois. (See p. 553, and Pl. 13, fig. 2, w-c. 1, n^6, etc.)

SECTION IX.

HISTOLOGY.

In a former section[1] we have demonstrated beyond question, that the embryonic disc, at the time of its formation, and the peripheric portion of the germinal layer, are composed of a uniform layer of consimilar cells (Pl. 9a, fig.

[1] See Part III., Chap. 1, Sect. 5, p. 479.

8, fig. 34, *a*, p. 522). This is true, as far as their appearance is concerned; but inasmuch as some are destined and tend to form one kind of organ, and assume features peculiar to the cells of that organ, and others form other organs and assume other very diverse features, it is impossible to deny that these apparently identical cells are at this time, respectively, very unlike in their intimate nature. The cells of the amnios, for instance, which we are about to describe, are totally different in appearance, at a certain stage, (Pl. 9a, fig. 28,) from all the other cells of the body, and retain their peculiarities throughout the whole period of the existence of the organ to which they belong; and yet these cells were once apparently identical with all the other cells in the embryo. Thus, premising that all the cells of which the embryo is composed have at one time a perfectly similar appearance, as far as our senses can perceive, we will proceed to describe the different changes through which these cells pass in the origin and development of the several organs.

The Amnios. At the time the amnios is nearly closed over, its cells (Pl. 9a, fig. 28) are arranged in a single layer. These cells are of moderate size, sharply polygonal, quite transparent, and nearly filled by a large, oval mesoblast; and the latter has perfectly homogeneous, clear contents, with a small, hollow, sharply defined entoblast in the centre. The mesoblast is not quite so transparent as the contents of the parent cell about it. These peculiarities are constant as long as the amnios exists, and by them the amnios may be recognized even at so late a period as when the Turtle is hatched; but then the cells are beginning to decompose, (Pl. 9a, fig. 31, *b*, fig. 31a, *b*,) and are slightly swollen.

The Spinal Marrow. The cells of the spinal marrow were not made the subject of a particular study, except at one stage, a short time before the Turtle was hatched, (Pl. 15, fig. 1, 2, 3,) and then only in one part of this organ, namely, just behind the medulla oblongata. These cells (Pl. 19, fig. 21) are very similar to those of the medulla oblongata, (fig. 20,) but some are more hyaline. No caudate cells were observed here, as in the medulla oblongata (fig. 20, *a*, *a*). The smaller cells are not mesoblasted.

The Medulla Oblongata. Our investigations of the cellular structure of the medulla oblongata, and of parts of the whole brain, were not commenced earlier than in the case of the spinal marrow. At this stage, the cells (Pl. 19, fig. 20, *a*, *b*) are irregular in outline, but more or less globular, and some have tail-like prolongations, forming the so-called caudate cells (*a*, *a*). The contents are light and finely granular, and surround a mesoblast, of variable size, which sometimes almost fills the cells (*b*).

The Hemispheres. The cells in this portion of the brain are variable in size and closely packed together, (Pl. 19, fig. 16b, 16c,) but not mutually compressed, so as to render them polygonal. At the surface (fig. 16b) of the hemispheres, they exhibit a pretty uniform contour. They have a perfectly globular shape, very transparent, faintly granular contents, and a single mesoblast, varying in size so as either to fill two thirds of a small cell, (fig. 16c, *a*,) or a small proportion of the larger ones. At the first glance, the mesoblast appears to be granulated; but closer scrutiny shows that this is owing to the granular contents of the parent cell, which lie in its immediate neighborhood. By the action of water, the cell wall becomes very irregular, (fig. 16c, *b*, *b′*, *c*, *c′*,) and the thickness of the wall of the mesoblast more sharply defined, and collapsed. At the time the Turtle is hatched, the cells (Pl. 19, fig. 16, *c*, 16a) are slightly polygonal, and mutually compressed. Each one has faint, granular contents, a large, single, clear mesoblast, and a minute, sharply defined, dark, oily-looking entoblast.

The Olfactory Lobes. The cells of the olfactory lobe, of the earliest stage noticed, were taken from the same brain as those of the medulla oblongata, the hemispheres, and the Schneiderian membrane. They are not so large as those (Pl. 19, fig. 16b, 16c) of the hemispheres, nor are they transparent, and the granular contents are darker (Pl. 19, fig. 18). The large, single mesoblast is perfectly homogeneous, but darker than the granular contents about it. A caudate cell (*a*) may be seen here and there, but very rarely. The action of water renders them irregular, like those of the hemispheres.

The Olfactory Nerve. At the time the young Turtle is hatched, the cells at the posterior end of the olfactory nerve, close to the olfactory bulb, are rather large, slightly elongated, and sharply polygonal (Pl. 19, fig. 17, 17a, 17b). They are very transparent, and have homogeneous contents, and each has a single, large, faint mesoblast. The walls have considerable thickness (fig. 17b). The elongation of the cells is in the direction of the axis of the nerve; this seems to indicate a tendency among them to arrange themselves in a linear series previous to the formation of nerve tubules. This tendency is carried out at the anterior end of the nerve, where there is no mistaking the relation which the nerve cells (Pl. 19, fig. 15) bear to the future nerve tubules. Here the cells are arranged in parallel lines, and have a more or less cylindrical shape, according as they are more or less united end to end, with the longer diameter running in the same direction as the axis of the nerve. Between the united ends of some of them, (fig. 15. *a*, *b*,) the walls are nearly obliterated, so that conjointly they form perfect tubules, the mesoblasts in some cells remaining distinct, to mark the position of the metamorphosed cells; whilst among others the walls stretch half-way across; and again others, though very seldom, have entire walls. They are quite transparent, although filled by scattered granular contents. The mesoblasts are identical with those at the other end of the nerve, but much fainter.

The Schneiderian Membrane. A short time before the Turtle is hatched, the cells of the Schneiderian membrane are very irregular, (Pl. 19, fig. 19, *a*,) and small, when compared with those of the olfactory lobe (fig. 18). They are very faintly and minutely granulated, and contain a comparatively large, irregular, clear, homogeneous mesoblast. In water they readily swell up to a much larger size, (fig. 19, and *b*,) and become more globular; but the mesoblast still retains its homogeneity and clearness.

The Pia Mater. At the earliest stage mentioned above, (p. 603,) the surface of the olfactory lobe was covered by a thin layer of elongated, fusiform, faintly granulated cells, in which no mesoblast was visible (Pl. 19, fig. 18a). Although these cells differ very much from those of the pia mater, over the hemispheres, at the time the young is hatched, (see Pl. 19, fig. 16, *a*, *b*, *c*,) yet, as they lie close upon the olfactory lobe, they cannot belong to any other membrane than the one in question. At the time the animal is born, the pia mater is quite thick, at least where it covers the hemispheres, and is composed of three layers of cells. The outer layer (Pl. 19, fig. 16, *a*) is quite uniform, and consists of large, pyriform, and excessively hyaline cells, each containing a large, very faint, homogeneous mesoblast. The two lower layers (*b*, *c*) consist of much smaller cells than the last. These cells are broad and irregularly prismatic, with faint, granular contents, but withal transparent. There was no mesoblast to be seen. At the point where this section was made, a bloodvessel (*d*) with an excessively thin wall, belonging to this membrane, passed along its lower surface close against the hemispheres. The blood corpuscles are slightly altered by the action of water.

The Chorda Dorsalis. At the stage when the dorsal vertebræ have developed along nearly the whole length of the body, (Pl. 12, fig. 5, 8, 9, 9a, 11, and p. 548,) the chorda dorsalis consists of elongated, fusiform, and very transparent cells, (Pl. 19, fig. 5c,) so arranged that their longer diameters trend transversely to the axis of the chorda. Their wall is very thin, but yet sharply defined. Soon, however, the walls increase in thickness, (Pl. 19, fig. 22,) and the cells broaden and become irregular in outline. At the time the brain begins to divide into lobes, (Pl. 18a, fig. 14, p. 552, 553,) and just before the heart has become three chambered, the cells of the whole length of the chorda (Pl. 19, fig. 5d) are very large, and more or less irregularly polygonal. Those at the surface (fig. 5, 5a, 5b, *a*) are very irregular, and in many instances as broad as long; they have a moderately thick wall, and mutually follow each other's outlines. In this way, lying close together, they form a continuous, smooth membrane, which incloses the looser interior cells. Where the wall of a single cell is in profile, (fig. 5, *a*, fig. 5a, *a*,) it is clear that there is no membrane exterior to the one formed by their own combination; and, again, it would seem that at the free surface of the cells (*a*) the wall is very thin, like that of the interior ones (fig. 5b, *b*). The interior cells are nearly globular in shape, and do not appear to press against each other. The walls are excessively thin, and their contents, as well as the contents of the superficial cells, are perfectly homogeneous, and hyaline. At no time, as far as we have investigated the cells of the chorda, could the least trace of a mesoblast be detected in them. No reagents were used in this investigation.

The Vertebræ. At the time the vertebræ have appeared along nearly the whole length of the embryo, and the branchial fissures have begun to develop, (see Pl. 12, fig. 5, 8, 9, 9a, 11, and p. 548,) each vertebra is composed of a single layer of cylindrical, wedge-shaped cells, (Pl. 19, fig. 3,) having their broader ends outward, and the narrower ends pointing towards the square, hollow, clear space in the interior. (See also p. 591, and Pl. 19, fig. 3.) Their contents are perfectly homogeneous and hyaline, without any trace of a mesoblast. At the time the Turtle is born, the peripheric portion (w-c. 12, a^2, p. 591) of the vertebræ is ossified to a certain depth. The outer, very elastic layer (Pl. 22, fig. 3, *a*) can hardly be distinguished from the unossified, fibrous lining of the shield; in fact, not at all, except by its hardness. These hardened, calcified fibres lie close to each other, but leave here and there numerous elongate-oval, clear spaces, which trend, with the fibres, in the same direction as the axis of the vertebræ. They consist of rows of minute granular bodies, containing, or in fact made up, of lime (fig. 3a). Transverse to the fibres of the outer layer, those of another layer (fig. 3, *b*) may be found lying closely pressed upon them, and similar in the arrangement of the fibres and of the clear spaces. A third fibrous layer (*c*) has clear spaces, the longer diameter of which trends in the same direction as in the third layer. The clear spaces of the second and third layer are more or less broad and irregular, resembling the very large and jagged, broad, oval, or round openings in the spongiform, innermost mass (*d*) of the bone. The fibres of the third layer (*c*) cannot be made out at all, and those of the second layer are very faint, whilst those of the first (*a*) are easily recognized. The meshes or interspaces of the spongiform, calcareous, innermost layer are very clear, and appear perfectly amorphous when seen in this position. From the manner in which the fibres of the torn edge of the first (*a*) and second (*b*) layers bristle out, each one supporting itself, it is made clear that the granules composing the fibres (fig. 3a) are the recipients of a calcareous deposit. This deposit gradually fills up the minute interspaces between the fibres, and thus forms a uniform, apparently homogeneous layer, (*c*,) with clear spots, scattered here and there, throughout the stratum. The appearance of the third layer (*c*) is so similar to the two outer ones, and to the second one in particular,—which only differs in showing very faint, granular lines, as if they were becoming obliterated,—that it can hardly be doubted that all three are similarly constituted, and that in the innermost one the fibres are totally obscured by the uniform deposit of lime. The same would naturally be said of the fourth, (*d*,) were it not that in a transverse section (fig. 4) of this layer an irregular, coarse, granular deposit (*d*) may very easily be seen. From this we should infer that the third layer (fig. 3, *c*) is, very probably, the basis of a transition state between the fibrous and amorphous modes of calcareous deposit. In respect to the mode of deposit of lime among the true cartilage cells, (fig. 4,) we would say, that, interior to the calcareous deposit (*d*) already present, the cells (*a*, *b*) have partial, granular linings, which extend over greater or less portions of the cells, and are seen either in profile (*a*) or with the outer or inner surface next to the eye (*b*). The fact that the granules are arranged along the wall of the cell would seem to indicate that there is a preparation going on for forming the meshes of calcareous matter. This is confirmed, in some instances, where the granular lining is in direct communication with the lime granules already deposited, at the edge of ossification (*c*). Since, however, nitric acid does not dissolve this lining, and moreover since a similar lining is disclosed when the lime is dissolved away from the cells in the already ossified portion, (*d*,) it is evident that it serves merely as a framework or basis, in which the lime is deposited. The large, single, homogeneous mesoblast may be seen not only in the unossified cells, (*a*, *b*, *c*,) but also (*e*) in those which are ossified (*d*). To show that the hardening of the vertebræ is due to lime, the nitric acid which was used to dissolve the coarse granules in this section was allowed to evaporate slowly, and the result (fig. 4a, *a*, *b*) proved to be the characteristic crystals of nitrate of lime.

The Ribs. The intimate structure of the ribs was not investigated until at the time the Turtle was hatched. By making a very oblique section (Pl. 22, fig. 1) of one side of a rib, from the surface to its centre, portions of the surface of all the layers of which it is composed were displayed very clearly. A transverse section (fig. 2) displays the thickness of the cells at right angles to the axis of the rib. The central cartilage cells (fig. 1, *a*, fig. 2, *a*) have a quite thick and dark wall, and contain each a sharply defined but faint, large, clear, homogeneous mesoblast, and a heap of coarse and fine granules. A little distance from these, the cell is flatter, (fig. 2, a^1,) and the wall, (a^1,) as well as the mesoblast, is fainter, and the heaps of granules more spread throughout the cell. Still further outward the cell is yet more flattened, (fig. 2, a^2,) and the wall is very faint (fig. 1, a^2). Finally, at the surface (fig. 1, a^3, fig. 2, a^3) of the cartilaginous mass, the cell wall is invisible, but the granules still retain a faint, cumulated arrangement. This layer is quite distinct from the mass of cells beneath it. Some of the cartilage cells do not fill the cavity in the matrix; and in such cases (fig. 1a, fig. 1b) the thick cell wall (*b*) may be seen passing across the cavity, sometimes at one end and sometimes at both. Close upon this, there rests a dense, fibrous layer, (fig. 1, *b*, *c*, *d*, *e*, *f*, fig. 2, *b*, *c*, *d*, *e*, *f*,) containing cells in various stages of development. The innermost of these cells (fig. 1, *c*) are irregularly round and very flat, (fig. 2, *c*,) so as to appear almost like dark lines in a transverse section, and each contains a rather faint, granular mesoblast; otherwise the contents are homogeneous. The irregular, wavy processes from these cells connect here and there with those of neighboring cells, and appear to be spaces in the fibrous substance; but whether they are direct prolongations from the cell could not be made out with certainty, although it appeared very probable that such is the case. A little further toward the surface of the bone, these cells are found to be elongate-oval (*d*) or oval, and not quite so flat (fig. 2, *d*) as those last mentioned, and the wavy processes are shorter, but the mesoblast is the same. Still further outward, the cells (fig. 1, *e*) are very much elongated, irregular in outline, and are as thick (fig. 2, *e*) as they are broad. Their mesoblasts have altogether disappeared, and the wavy prolongations are very faint. At the surface of the middle line of the rib, the cells (fig. 1, *f*) are very long and slender. At the edge of the rib (fig. 1, *g*) the surface cells are like those at the middle line, but they are much more slender. They cannot be distinguished very readily from those in the soft, fibrous corium, except that the latter are in a yielding matrix, whilst the former are surrounded by a hardened substance. The fibres (g^1) of this outermost layer, as well as those (h^1) of the corium, are composed of rows of minute granules. The fibres of the more interior layers are very faint. As these investigations were made upon perfectly fresh bones, and no reagents were used, it is clear that the mesoblasts of the cells in the fibrous layers are perfectly normal, and fully show that bone lacunæ, with their characteristic canaliculi, are nothing less than these mesoblasted cells, with their wavy processes anastomozing with each other.

The Limbs. Soon after the shield begins to form, and the feet begin to show external signs of the toes, (Pl. 25, fig. 11, and p. 565,) the bones of the feet, or rather their cartilaginous matrices, are quite conspicuous. The terminal or claw bones have not yet appeared. The matrix of each bone is composed of very irregular cartilage cells (Pl. 21, fig. 22, 24). Those in the centre are set at a considerable distance from each other, but as they approach the surface of the matrix they approximate, and at the same time gradually assume the smaller size and form of those in the surrounding tissue (fig. 25). Each cell contains fine granular contents and a large, round, clear mesoblast, which contains one or two entoblasts (fig. 22a). A short time before the Turtle is hatched, the terminal bones (Pl. 21, fig. 21) of the feet have not yet assumed the cartilaginous state, but are composed of sharply polygonal cells (fig. 21a) in contact with each other. Each cell contains a large mesoblast occupying half its diameter, and numerous entoblasts. Just before hatching, the centre of the bones of the limbs contains pure cartilage cells (Pl. 22, fig. 5, 6, 6a, 6b). The intercellular substance, or blastema, (*a*,) so called, occupies a large amount of space, when contrasted with the size of the cells (*b*). These cells are very irregular in shape, varying from spherical, semiglobular, trianguloid to elongate-oval, and each one contains a large, faint mesoblast. The principal point of interest is the granular basis for lime deposits in the form of a central heap, with branches stretching out in various directions. Some of the cells (fig. 6) also contain faint granules throughout their whole length and breadth. The application of alcohol brings out more clearly the faint granules, (fig. 6a,) and also those arranged in a branching manner. In some instances, the cells thus treated shrank away from the surface of the cavity of the blastema (fig. 6a, *c*, 6b).

The Skin. At the time the branchial fissures begin to form, and the eye to develop, (Pl. 12, fig. 5, 8, 9, 9a, 11,) the surface of the tail consists of hyaline, oval cells, (Pl. 19, fig. 2,) each one of which contains a small, sharply defined, single mesoblast. A little later, the cells on the head, near the eye, are large, cylindrical, thin walled, and hyaline, and appear to have no contents whatever that may be seen, not even a mesoblast. They form but a single stratum, and have scattered between them minute hyaline granules. Considerably later than this, (Pl. 14, fig. 2, 2a,) the cells of the dermal layer (Pl. 19, fig. 4, *f*) are globular, hyaline, and contain each a single, dark mesoblast (see fig. 7, *b*).[1] When water is applied to these cells, the mesoblast becomes resolved into two bodies,— one very transparent, and the other dark and granular (fig. 4, *a*). When the toes begin to develop, (Pl. 25, fig. 11,) the cells of the surface of the feet are globular, faintly granulated, and contain a large, single, clear mesoblast, and a single entoblast (Pl. 21, fig. 23). The internal tissue of the feet is composed of cells similar to those of the shield (fig. 26). At this time, the cells of the skin of the carapace are elongated, irregular, finely granulated, and each contains a large mesoblast and a central, single entoblast (Pl. 21, fig. 26). That portion of the skin which is metamorphosed into claws (Pl. 21, fig. 20, *a*) is composed of very large, transparent, irregularly polygonal cells, each one of which contains a minute, irregular mesoblast, situated at its surface, and a dot-like entoblast (fig. 20a, 20b, 20c). The cells (fig. 20, *b*) beneath this horny sheath and at the base of the toe (*b'*) are large, (fig. 20d,) but yet much smaller than those of

[1] Although this is a blood corpuscle, it is apparently identical with the cells of the dermal layer.

the claw (fig. 20, *a*). They are sharply polygonal, and contain minute scattered granules, a single, large, round mesoblast, and a minute entoblast (fig. 20d). In the last phase, just before the Turtle is hatched, the cells of the epidermis of the shell are (Pl. 20, fig. 18, on the right) sharply polygonal; they have very thick walls, and appear to be perfectly homogeneous. Underneath these are very large, hyaline, excessively thin-walled, polygonal cells (fig. 18, on the left). Each cell contains a central heap of very dark granules, which extend in a scattered manner to the walls of the cell.

The Eye. Soon after the eye has begun to develop, (Pl. 12, fig. 6; p. 550,) the cells of the retina (Pl. 21, fig. 28, *a*) are columnar, narrow, elongated, and arranged with their longer axes trending perpendicularly to the parietes of the cavity which they surround. Each cell occupies the whole thickness of the retinal layer. At a much later period, when the shield has become quite conspicuous, (Pl. 14, fig. 1,) and the toes begin to protrude from the paddle-shaped feet, the cells (Pl. 21, fig. 30) of the crystalline lens are excessively hyaline, and have homogeneous contents without a trace of a mesoblast. They are arranged in lines, which run from the anterior to the posterior side of the lens, and converge around a centre (*a*) where the cells are smallest, so that a fibre of the lens may be said to be an exceedingly long, fusiform body, composed of cells arranged in a single line. A short time before the Turtle is hatched, (Pl. 15, fig. 1, 2, 3,) the membrana pupillaris is composed of very large, polygonal cells (Pl. 21, fig. 29, *a*). The crystalline lens (fig. 32) is composed of long, ribbon-shaped, flat fibres, (fig. 32b, 32c,) containing scattered, faint granules. Each fibre runs from the anterior to the posterior side of the lens, those at the centre in a straight line, and those exterior to them more and more in a curve, according as they are nearer the surface. Every one is composed of excessively transparent, thick-walled, quadrilateral cells, (fig. 32a,) to display which requires the agency of water, since in a fresh state they cannot possibly be detected, except that portion of the wall which forms the edge of the fibre (fig. 32b, 32c). A few exceedingly transparent, large, globular bodies are scattered among the fibres; but even these must be brought out by the agency of water. By the continued action of water, the cells swell up enormously (fig. 31, 32d). This can only be accounted for by the thickness of the walls of the cells, in a natural state, which allows such great extension without tearing. At the time the Turtle is hatched, the retina is nearly as complicated as in the adult. A section of the thickness of the retina was made at a point half-way between the crystalline lens and the back of the eye.

Immediately behind the hyaloid membrane, (Pl. 22, fig. 8, *k*,) the surface of the retina is covered by a thin layer (fig. 8, *i*) of excessively elongated fibres, which seem to run from the entrance of the optic nerve (fig. 8, *h*[1]) to the anterior edge (*i*[3]) of the retina. In the section, (Pl. 21, fig. 33.) these fibres were found to be slender, tail-like prolongations of the cells (*b*) next to the inner surface of the retina. The whole thickness of the retina is made up of five apparently distinct layers of cells; but this is true only in a certain respect, as the following separate description of each of them will show. The innermost layer (*b*, *c*) is about one quarter as thick as the whole retina, and is composed of large, hyaline cells, each containing a large mesoblast. The general contour of these cells is globular, but either the outer or the inner end, and sometimes both, are prolonged into tail-like processes, which, in the case of those on the inner surface of the retina, form the fibrous layer above mentioned, or project (*c*) so far into the next outer layer (*d*) as, at times, almost to reach the layer beyond (*e*, *f*). The next outer layer (*d*) is only two thirds as thick as the first. It is composed of excessively thin-walled cells, which are hardly larger than the mesoblasts of the cells in the inner layer. Exterior to this, the third layer (*e*, *f*) is a little thicker than the innermost one, (*b*,) and appears to be identical in structure with it, except that the cells are a little more elongated, and spindle-shaped. Its cells send projections (*e*) both into the second layer (*d*) and (*f*) into the next outer or fourth one (*g*). The fourth layer (*g*) is about as thick as the second, (*d*,) and, except that the cells are much smaller, they are just like those of the first (*b*) and third (*e*, *f*) layer. Here and there the tail-like prolongations of these cells project, (*i*',) even to the outer surface of the membrana Jacobi (*h*, *i*). The outermost layer, the membrana Jacobi, (*h*, *i*,) is composed of two kinds of cells: the first kind are those (*i*) which resemble the cells in the next inner layer, (*g*,) except that no mesoblast is visible, and they send tail-like prolongations (*i*) into the layer next within, and also outwardly to the surface of the layer to which they belong; the other kind of cells do not project into the layer beneath. They are long and club-shaped (*h*, fig. 33a, *a*, *b*, *c*); some of them terminate suddenly in a thick end, (fig. 33a, *b*, *c*,) where a large yellow or orange mesoblast is situated; others have a long, slender projection at both ends, (*a*,) and the yellow mesoblast is situated at the thickest part of the cell. These last are by far the most numerous cells in the layer. The colored mesoblasts are so situated that they are all on the same level; and they vary in intensity of color, from almost white to the deepest orange red. In no instance has it been possible to find the cells of the retina forming a continuous fibre, extending from the inner to the outer surface, as has been observed by Kölliker and H. Müller in Mammalia. (Compare Wagner's Icon. Phys. 3d Lief. 1854.) In the adult Turtle, the cells of the retina are very similar to those just described, except that their prolongations are more slender.

The Ear. Soon after the ear has begun to develop, (Pl. 12, fig. 6,) the cells (Pl. 21, fig. 27) of the cup-shaped tympanic cavity are identical, in every respect, with those of the eye (fig. 28).

The Intestine. A short time before the Turtle is hatched, the mucous layer of the œsophagus is composed of two layers of cells. The superficial ones (Pl. 21, fig. 1, fig. 5, *a*, fig. 6) are simply irregularly oval, or round, and have faint, granular contents. Their free surfaces are furnished with numerous vibratile cilia. By the application of water, the single mesoblast, and the single, double, or triple entoblast are brought out, (fig. 7, and 8,) and the mesoblast of the columnar cells may be recognized through the superior layer (fig. 8). The inferior layer (fig. 5, *b*) consists of long, cylindrical cells, (fig. 2, fig. 5, *b*,) with scattered granular contents, and a single, homogeneous, hyaline mesoblast, situated near the broader end. Whilst in place, these cells are prismatic from mutual pressure, but being set free, they assume an irregular, club-shaped or spindle form (fig. 2). The superficial epithelial cells (fig. 14e) of the stomach, when seen endwise, appear sharply polygonal, of moderate size, and filled by densely packed granules, which almost obscure the large, single, oval mesoblast (fig. 14d). When seen in profile, they are deeper than broad (fig. 14c). By the action of water, these cells swell, and the granules are scattered (fig. 14f, 14g) so as to expose the dark, granulated mesoblast. By rolling these cells along the field of the microscope when they are very much swollen by water, it may very readily be seen that the mesoblast is attached to the wall of the cell (fig. 14g, *a*). By careful manipulation it was ascertained that the vibratile cilia on these cells are not scattered promiscuously all over the free surface, but form a crown to each one (fig. 3, and 4) along the line, where each cell touches its neighbor. The elongated cells of the thick intestine are arranged end to end, in three layers (fig. 34). They contain numerous, minute granules, and, when seen endwise, appear sharply polygonal (fig. 34a). If slightly acted upon by water, the large mesoblast is brought out quite clearly.

The glands of the stomach appear as more or less elongated openings on the inner surface of the mucous membrane (fig. 14, *a*, 14a, 14b, 15, 15a). Around each opening a dark ring may be seen; every ring touching its neighbor: this is the outline of the gland seen through the thickness of the epithelium. By plunging the microscope deeper, toward the outer surface of the stomach, the elongated, oval cells (fig. 15, 15a, *b*, 16a) of the glands may be seen radiating from around the central cavity. Each gland is about four times as deep as broad, and consists of but one layer of cells (fig. 16b). These cells, in a view of the exterior surface of the gland, are irregularly polygonal; they contain a few scattered granules, and each a large, round, dark mesoblast in the centre. In a profile view they appear elongated, with the longer diameter trending in the direction of the thickness of the wall. At the time the animal is hatched, the epithelium, (fig. 10,) at the base of the tongue, is a layer of rather irregular, polygonal cells, containing a moderate sized mesoblast, and a minute, granule-like entoblast. These cells vary considerably in size, and so does the mesoblast. In a transverse section of a fold of the œsophagus, (fig. 11,) we have, first, on the surface, a layer of epithelial cells (*a*) that are broader than deep, and each one of which is crowned with a row of vibratile cilia (fig. 12) arranged along the line of contact with the neighboring cells, so that their free surface is naked. Next beneath these is a thick layer of long, irregular, columnar cells, (fig. 11, *b*,) the longer diameter of each occupying the whole thickness of the layer; and, outside of these, irregularly rounded, homogeneous, transparent cells, (*c*,) which fill up the space in the angle of a fold, and also form a thin layer between the columnar cells (*b*) and the muscular coat (*d*). The cells of the muscular coat (fig. 13) of the œsophagus are excessively long, slender, and spindle-shaped, and lie so closely pressed together that their long, slender ends cannot be well seen, unless they are separated (fig. 13a). With a magnifying power of eleven hundred diameters, the cell wall appears only as a rather thick, dark line. The mesoblast occupies nearly or altogether the whole breadth of the cell; it has a quite thick wall, (*a*,) and contains a sharply defined, single entoblast (*b*).

The mucous membrane of the stomach is made up of at least four layers of cells, (fig. 17, *a*,) piled one above the other, so as to resemble columnar cells. Those next the inner surface of the stomach are the largest; and, proceeding thence outwardly, they grow smaller. The mucous membrane of the thick intestine is composed of no less than six layers of cells (Pl. 21, fig. 18, *a*–*a*′). In those cells which are next to the surface, (*a*′,) the mesoblast is very easily seen; but in the other more exterior cells it is very faint. By separating a few columns of cells, (fig. 18a, 18b,) not only may their relations be better shown, but the clear, round mesoblast, and its sharply defined entoblast also become visible. These cells are placed so regularly one above the other, that they resemble a long columnar cell. When seen in a mass, through considerable depth, they appear oval, with the longer diameter of each trending in the same direction as the columns (fig. 18); but, taken singly at a fixed focus, their more or less polygonal shape (fig. 18a) may be recognized. Those at the surface (fig. 18, *a*′) are the largest, and those at the outermost side, (*a*,) nearest the muscular layers, (*c*, *d*,) are a great deal smaller; and between these two extremes there is a regular gradation. Here and there a few cells were found in a state of self-division (fig. 18c, *a*, *b*); some (*a*) had two distinct mesoblasts and a strong median constriction, made more conspicuous by the total absence of granules at that point, and others (*b*) had but a single, clear, distinct mesoblast, probably the old one, near one end, and at the other, on the opposite side of the constriction, a very faint one, without doubt just forming. By this we may very readily account for the fact that there are but two layers of cells (fig. 11, *a*, *b*) in the œsophagus; while there are four layers (fig. 17, *a*) in the stomach, either four or five (fig. 19, *a*, *a*) in the long intestine, and six here (fig. 18, *a*, *a'*). Directly beneath the mucous membrane is a layer of rounded, loosely packed cells, (*b*,) identical, to all appearance, with those seen in the same relation in the œsophagus (fig. 11, *c*). Next, and farther outward, is the layer of constrictor muscles, (*c*,) composed of elongated, fusiform cells, similar to those of the same layer in the œsophagus, (fig. 11, *d*,) which trend in a direction transverse to the axis of the intestine. Just exterior to this is another layer of muscle, (*d*,) which is composed of similar cells, but they trend at right angles to the last, and therefore along the intestine. In a transverse section of the intestine, these cells are cut across, so that their shorter diameters are exposed. A thin, apparently amorphous membrane (*e*) incloses the whole intestine. The mucous membrane (fig. 19, *a*) of the long intestine, at a point about one third of its length behind the stomach, hardly differs from that of the thick intestine, (fig. 18, *a*, *a'*,) except that the layers of cells are only four or five in number, and the cells a little smaller. The rounded, loosely packed cells (*b*) just outside of the mucous membrane (*a*) are also a little smaller than in the thick intestine; but the muscular layers (*c*, and *d*) and the enveloping membrane (*e*) do not appear to differ. The glands of the stomach are very much elongated, and more or less convoluted (fig. 17, *b*, *c*, *d*). Their walls are composed of cells, which are identical in every respect with those of the mucous membrane, (*a*,) of which they are a direct continuation. When the gland is perfectly straight, the cells (*c*) on its inner surface are as large as those (*a*) on the surface of the stomach; but where the gland bends, those in a similar position at the inner angle of the bend (*d*) are compressed, whilst those at the outer convex surface of the curve are the largest. The cavity (*b*) of the glands is very narrow, from its opening to its bottom.

The Allantois. A short time before the young are hatched, the allantois is composed of two layers. At a point near the body of the embryo, the inner one (Pl. 9a, fig. 30) of the two is made up of rather large, thick-walled, irregularly polygonal cells, filled by minutely granular but transparent contents. The outer layer (fig. 30a) is distinguishable only on account of its numerous dark granules, which are arranged in heaps; the cells which, in all probability, surrounded them, could not be discovered. At a point more distant from the embryo, the cells of the inner layer (Pl. 18a, fig. 3) are larger and more elongated, and lozenge-shaped, and have thicker walls. The outer, granular layer is very distinct, and contains the bloodvessels.

The Urinary Bladder. At the time of hatching, the mucous membrane of the bladder is composed of five layers of cells, (Pl. 20, fig. 13, 13a,) very similar to those of the long intestine, (Pl. 21, fig. 18, 18a, 18b,) the only difference being that there is one layer less, and that the cells of the several layers are more strictly on a level with each other (Pl. 20, fig. 13a). When seen from the inside of the bladder, the superficial cells (fig. 15) appear more or less polygonal, but yet their walls are slightly rounded. The mesoblast of some of them is elongated, and contains two entoblasts, an arrangement which is often indicative of a tendency to a self-division of the cell. In an expanded state of the bladder, the cells lose in a measure their polygonal shape (fig. 13). The muscular coating (fig. 16) is a mesh-work of superposed fibres, which run in every possible horizontal direction. These fibres are composed of elongated, fusiform cells, (fig. 14, 14a,) of variable length, according to their position. The outermost fibre cells are lozenge-shaped, about twice as long as broad, and excessively transparent. The large, round mesoblast is not so faint as the cell, and the entoblast, sometimes double, is sharply defined. The rest of the whole muscular system is composed of elongated, spindle-shaped cells, (fig. 14,) with faint, granular contents and a large mesoblast occupying nearly the whole width of the cells, which have none of the long, thin, tail-like prolongations seen in the œsophagus (Pl. 21, fig. 13, 13a).

The Lungs. At the time the lungs have fairly separated from the intestine, (Pl. 24, fig. 2, *l*, *l'*, and fig. 2a,) the inner wall, or mucous membrane, (Pl. 20, fig. 12, *b*,) is composed of a single layer of broad, cylindrical cells, with rounded outer ends. A short time before birth, the mucous membrane is composed of a single layer of cells, (Pl. 20, fig. 7, 9, *a*, 11, *a*,) of variable size, in different portions of the lung. They contain very scattered, granular contents, and vary in shape; some being broader than deep, (fig. 9, *a*, 11, *a*,) and others (fig. 7) much deeper than broad. The contractile tissue (fig. 10, *b*, 11, *b*) is a delicate, fibrous mesh, forming, with the mucous membrane, (fig. 11, *a*,) the walls of the cavities. The bloodvessels (fig. 10, *c*) do not follow the trend of the fibres of the mesh, but run at various angles across them, and in close proximity to the mucous membrane (fig. 7). The outer surface of the lung is covered by a thin layer of very pale, round cells, (fig. 9a, 11,) which do not touch each other, but are separated by numerous dark granules. Besides these, the surface is mottled, principally over the course of the bloodvessels, (fig. 5,) by numerous pigment cells, (fig. 8, 9a, 11,) which are nothing more than the pale cells, around which much darker granules are densely packed, in such a manner as to assume the appearance of an irregular two, three, four, or five-rayed star.

The Trachea. A short time before birth, the cartilage rings of the trachea, (Pl. 24, fig. 6) are composed of quite thick-walled cells, which contain numerous minute, dark granules (Pl. 20, fig. 6). The cells are as yet in close contact with each other, and have sharp, polygonal contours. At birth, the cartilage cells (fig. 3, *b*) are widely separated from each other by the development of an amorphous, intercellular substance. At the middle (*b*) of the ring, these cells are more or less rounded; but, as they approximate the fibrous bands (*a*) which alternate with the rings, they gradually flatten, and diminish in size, till, at the edge (*c*) of the layer, they are mere thick, dark lines. The fibrous bands (*a*) consist of very fine threads, or strings, of granules, interwoven, and oftentimes crossing each other at very broad angles.

The Liver. A short time before the Turtle is hatched, and about the period when the allantois has surrounded the whole yolk sac, the cells (Pl. 19, fig. 32) of the liver are moderate in size and polygonal. They are filled by densely crowded, dark granules, in the midst of which is a clear, round mesoblast. When separated from each other and immersed in water, they assume a spherical form (*a*, *b*, *b'*, *c*, *c'*). Just before birth, the liver cells are much larger than those mentioned here. They are more or less polygonal, and contain a crowded mass of coarse, dark, oily looking granules and a bright yellow mesoblast, with a minute, sharply defined entoblast (fig. 31, *a*). When isolated (*b*) from each other, and treated with a little water, they show that they have (*a*) very thin walls and a rather opaque but bright yellow mesoblast.

The Gall Cyst. At the last stage mentioned, the wall of the gall cyst is a single layer (Pl. 19, fig. 29) of cylindrical, wedge-shaped cells, with the broader ends next to the outer surface (*a*) of the wall. They are very transparent, and contain scattered, faint granules and an excessively hyaline mesoblast near the broader end. Seen endwise, they appear polygonal (fig. 29a).

The Bloodvessels. Just after birth, a bloodvessel that had been isolated from the pia mater had an excessively thin wall, (Pl. 19, fig. 14,) which appeared to be built up of excessively hyaline, polygonal cells, each one of them containing a large but rather faint mesoblast and perfectly homogeneous contents. In some places, the mesoblast appeared in profile (*a*, *b*); yet outside of it no wall, but that of the cell. could be detected.

The Genital Organs. Just before the Turtle is born, the ovary (see p. 573 and Pl. 25, fig. 7, *n*) is composed of moderately large, polygonal, and extremely transparent cells, (Pl. 19, fig. 30,) each one of which contains a large, densely granulated mesoblast.

The Kidneys. By the time the embryo can freely move its eyes, jaws, and toes, (see p. 565, and Pl. 18a, fig. 2 and 3,) the Malpighian bodies (Pl. 20, fig. 2) of the kidneys are pretty far advanced. The bloodvessels (*b*) do not form a convoluted glomerulus in the end of the uriniferous tube, (*a*, *a′*, *a″*,) but in a swelling situated at a certain point in its track. The cells of the wall of the Malpighian body are short and broad, and form only a single layer (*a*, *a″*). The bloodvessels in the glomerulus are very closely crowded, and tortuous. Only a single vessel, whether artery or vein could not be determined, was seen in connection with the glomerulus.

The Wolffian Bodies. A short time before birth, the uriniferous tubes of the Wolffian bodies are composed of very large, irregularly polyhedral cells, arranged in one layer (Pl. 20, fig. 1, 1a, 1b) around a rather large, central channel (fig. 1, *a*). In a transverse section, these cells appear broadly wedge-shaped, with the narrower end next to the central channel (fig. 1, 1a). Where the tube bends upon itself, the cells all converge around one point, so that the inner ends of some may be seen in the centre, (fig. 1a,) and the channel in the distance. At this stage, the uriniferous tubes are very long and slender, and may be very easily traced from the central canal, or duct, (Pl. 25, fig. 5, *c*,) to the point (*a*) where they bend upon themselves, at the parietes of the Wolffian body, and return to the channel whence they started. The uriniferous tubes (*b*) of the kidneys are very short and thick, and are much less numerous than those of the Wolffian bodies. They also run outward, and back toward the duct, (*c*,) but we are not sure that they empty into it.

The Blood. About the time the heart begins to lose its tubular character, and the eyes and ears have become decidedly marked and conspicuous, (Pl. 12, fig. 6c, and p. 550,) the blood corpuscles are mere globular, minute, transparent cells (Pl. 19, fig. 6, 7, *a*, *b*).[1] This shape and size they retain for some time, at least until the allantois has nearly covered the embryo, (Pl. 14, fig. 2, 2a,) and the lungs (Pl. 24, fig. 2, 2a) have become separated from the intestine, and begun to assume a sac-like shape. In a natural state, these corpuscles (Pl. 19, fig. 7, *a*, *b*) are perfectly globular and transparent, and each contains a large, apparently granulated mesoblast attached to the wall (*a*). By the application of water, the mesoblast bursts, (*c*, *d*, *e*, *f*, *g*, *k*, *i*, *j*,) and the whole granular contents come out, but still retain their globular state, and appear to have a membrane about them (*j*). From this it would seem that the apparently granular contents of the mesoblast constitute, in reality, an entoblast which fills the mesoblast. The blood corpuscles do not attain to the characteristic oval and flattened shape of the adult (fig. 8, *a* to *i*) until very late. At a certain stage, (see Pl. 15, fig. 1, 2, 3, and

[1] Fig. 7, *a*, *b* belong to a little later stage; but, as the blood corpuscles which they represent are identical with those of this stage, it would be superfluous to repeat the figures.

p. 570,) there is a mixture of oval, flat, disc-formed corpuscles (Pl. 19, fig. 12, *a*, *b*) with those which are oval and partially flattened, (fig. 9, 10, *a*, *b*, *c*, *c′*,) whilst others, although oval, are not flattened in the least (fig. 11, *a*, *b*, *c*, *d*, *e*). These last (fig. 11) are evidently derived from the elongation of the globular corpuscles of earlier stages (fig. 7); for, except in shape and a little difference in size, the two kinds differ but very little. An end view (fig. 11, *c*, *d*) of the oval corpuscles is not distinguishable from that of globular forms, (fig. 7,) except that in the oval ones the mesoblast is not lateral, but central. In order to become disciform, as in the adult, the corpuscles gradually flatten, (fig. 9, 10, *a*, *b*, *c*, *c′*,) until the two opposite sides almost touch each other (fig. 12, *a*, *b*, fig. 13, 13a, 13b, 13c). At this period, they have a remarkably plastic nature, and, when in contact, mutually flatten against each other, (fig. 13, 13a,) or stretch out to a considerable extent, (fig. 13b,) if they catch against any thing whilst floating on the stage of the microscope. The mesoblast is very faint and perfectly homogeneous in the most advanced phase, a short time before the birth of the Turtle. Finally, in the adult, the blood corpuscles (fig. 8, *a* to *i*) are quite flat (*c*); but the centre is not depressed, as would appear from a side view (*a*, *b*). The clear, homogeneous, light mesoblast contains a much darker entoblast. In water, the walls of the parent cell, the ectoblast, (*i*,) collapse, and the mesoblast and entoblast blend into one darker mass. By drying, the thickness of the parent cell (*h*) becomes sharply defined, and very conspicuous.

The Muscles. A short time before the Turtle is hatched, the muscles differ in the degree of development to which they have arrived in various parts of the body. At the point where the dorsal muscles are attached to the arch of the vertebræ, they consist of a mass of spindle-shaped cells, attached obliquely to each other, (Pl. 19, fig. 23, *b*,) or of very long, slender cells (*a*). The former (*b*) resemble the cells of the dorsal arch, (*c*,) and have a large, oval mesoblast, which contains numerous granules; the latter have lost their mesoblast, and have become so intimately united to each other as to obliterate the intervening walls, and thus assume the appearance of long, slender cells. Some of the mesoblasted cells are thus united to those without mesoblasts. The granular contents of these united cells have a more or less linear arrangement. Presently we shall see what this peculiarity tends to. In the foreleg, the muscular fibres have all the characteristic appearances of the adult. The longitudinal and the transverse striæ of the fibres are readily seen (Pl. 19, fig. 25, *a*). The fibrillæ (fig. 25, *b*) which constitute the fibres (*a*) are mere strings of very minute granules, such as we saw in another part (fig. 23, *a*, *b*) of the body, near the dorsal arch. Here, however, they are more regularly arranged in lines, but have not lost their granular, rounded appearance. By maceration in water, the membranous sheath of the fibres (fig. 24, and *a*) becomes quite conspicuous, and distends so as to leave the mass of disturbed fibrillæ floating free in the centre. Just before birth, the muscular fibres of the upper retractor muscle of the head are very transparent (fig. 27). When the fibrillæ are not disturbed, they are excessively transparent, and represented by the light spaces between the faint, parallel, longitudinal lines which may be seen in every part of the fibre; but where they are displaced, their component granules are separated or dislocated, and thrown into zigzag lines (fig. 27a). The granules are then easily recognizable. Treated with very weak alcohol, the undisturbed fibrillæ gradually display their component granules in close and continued series. Where the granules had been disturbed and separated from each other, before the application of alcohol, spaces were left between them, as the application of this reagent proved.

The Tendons. A short time before birth, the tendons of the foreleg consist of very slender, spindle-shaped cells, packed closely together (fig. 26, 26a). They do not appear to have united, as yet, to form the slender fibrillæ of the adult tendon.

SECTION X.

CHRONOLOGY OF THE DEVELOPMENT OF THE EMBRYO.

In the higher Vertebrata, the progress of the embryo is generally so regular, that the investigator, knowing the period of gestation or of incubation, is at the same time certain to find the different parts of the germ proportionally developed. This is not the case with the Testudinata, at least not so strictly; since the embryonic growth may be retarded for weeks, and the period of hatching postponed for months. In order, therefore, that the reader may see at a glance what figures belong to any particular phase, we give below a list of our figures, arranged according to their actual degree of development, in stages, and have affixed the dates of the time when the eggs were laid, and when they were opened and drawn. By this, it may be seen that age tells very little respecting the real degree of development of the embryo; but that the actual inspection of the structure of the organs is necessary, in order to ascertain whether any two or several embryos are equally developed. The duration of the growth of the ovarian eggs has already been discussed. (See p. 490 and 496.) For the names of the different species, see the Explanation of the Plates.

First Stage. Pl. 10, fig. 12, taken from the oviduct and drawn at once, June

4, 1852; fig. 13, and 14, taken from the oviduct and drawn at once, June 3, 1852; fig. 15, and 15a, taken from the oviduct and drawn at once, May 29, 1854. Pl. 9a, fig. 34, date of laying not known, opened June 12, 1854. Pl. 9e, fig. 1; (see Pl. 10).—p. 535.

Second Stage. Pl. 11, fig. 1, and 1a, laid June 21, opened June 26, 1855; fig. 6, and 6a, laid and opened July 3, 1855. Pl. 9e, fig. 2; (see Pl. 11, fig. 6).—p. 536.

Third Stage. Pl. 11, fig. 2, no date,[1] opened June 15, 1854; fig. 7, 7a, and 7b, laid July 2, opened July 3, 1855; fig. 8, and 8a, laid July 10, opened July 12, 1855; fig. 9, 9a, and 9b, laid and opened July 4, 1855; fig. 10, 10a, 10b, and 10c, laid July 2, opened July 3, 1855.—p. 537.

Fourth Stage. Pl. 11, fig. 3, and 3a, no date, opened June 12, 1854. Pl. 9e, fig. 3, and 3a; (see Pl. 11).—p. 538, and 543.

Fifth Stage. Pl. 11, fig. 4, 4a, and 4b, no date, opened June 12, 1854.—p. 538, and 543.

Sixth Stage. Pl. 11, fig. 5, 5a, 5b, and 5c, laid June 23; fig. 5, opened June 26; fig. 5a, opened June 27, 1855. Pl. 9e, fig. 4, 4a, and 4b; (see Pl. 11).—p. 539, and 543.

Seventh Stage. Pl. 12, fig. 1, and 1a, laid June 12, opened June 28, 1855. Pl. 9d, fig. 1; (see Pl. 12). Pl. 9e, fig. 5; (see Pl. 12). Pl. 24, fig. 13, 13a; (see Pl. 12).—p. 544.

Eighth Stage. Pl. 12, fig. 2, laid June 12, opened June 26, 1855. Pl. 9e, fig. 6; (see Pl. 12).—p. 546.

Ninth Stage. Pl. 12, fig. 3, 3a, 3b, and 4, no date, opened June 24, 1852.—p. 547.

Tenth Stage. Pl. 12, fig. 7, no date, opened July 28, 1852.—p. 547.

Eleventh Stage. Pl. 12, fig. 5, no date, opened June 25, 1854; fig. 8, laid July 18, opened July 30, 1852; fig. 9, and 9a, laid July 15, opened July 26, 1852; fig. 11, laid July 11, opened July 22, 1852. Pl. 14, fig. 12, no date, opened June 25, 1854. Pl. 19, fig. 2, (see Pl. 12, fig. 11,) and fig. 3, 5c, and 22, laid July 18, opened July 27, 1852.—p. 548.

Twelfth Stage. Pl. 12, fig. 10, 10a, 10b, and 10c, laid July 18, opened July 27, 1852. Pl. 13, fig. 10, and 11, laid June 18, opened July 11, 1855. Pl. 14, fig. 11, no date, opened July 11, 1855.—p. 549.

[1] No date means that the date of laying could not be ascertained. Eggs were frequently obtained from the fields under circumstances which made it impossible to ascertain the precise period when they were laid. They were nevertheless very useful, as they exhibited a most striking general coincidence with those raised in confinement, and, on that account, added to the value of these in the investigation.

Thirteenth Stage. Pl. 12, fig. 6, no date; opened July 28, 1852; fig. 13, laid July 18, opened July 28, 1852. Pl. 19, fig. 1, 6; (see Pl. 12, fig. 13). Pl. 21, fig. 27, and 28; (see Pl. 12, fig. 13). Pl. 9a, fig. 28; (see Pl. 12, fig. 6). — p. 550.

Fourteenth Stage. Pl. 9e, fig. 7; (see Pl. 18). Pl. 18a, fig. 11, and 12, laid July 14, opened Aug. 2, 1852; fig. 13, laid July 15, opened July 26, 1852; fig. 14, laid July 10, opened July 20, 1852. Pl. 18, fig. 5, and 7, laid July 11, opened July 22, 1852. Pl. 24, fig. 8, laid June 22, opened July 22, 1852. — p. 551.

Fifteenth Stage. Pl. 18a, fig. 14, laid July 10, opened July 20, 1852. Pl. 19, fig. 5, 5a, 5b, and 5d, laid July 10, opened July 20, 1852. — p. 552.

Sixteenth Stage. Pl. 13, fig. 2, no date, opened Aug. 3, 1852; fig. 3, laid June 18, opened July 10, 1855; fig. 8, laid June 12, opened July 11, 1855; fig. 12, laid June 18, opened July 10, 1855. Pl. 14, fig. 6; (see Pl. 13, fig. 12). Woodcut 1. — p. 553.

Seventeenth Stage. Pl. 24, fig. 7, and 7a, no date, opened July 30, 1852; fig. 14, laid July 14, opened August 2, 1852; fig. 15, no date, opened July 31, 1852. Pl. 18a, fig. 11, 12; (see Pl. 24, fig. 14). — p. 554.

Eighteenth Stage. Pl. 14, fig. 5, laid June 18, opened July 17, 1855. Pl. 17, fig. 5; (see Pl. 24, fig. 9, and 9a). Pl. 24, fig. 1, and 1a, no date; fig. 9, 9a, and 12, no date, opened August 6, 1852, p. 555.

Nineteenth Stage. Pl. 14, fig. 4, laid June 20, opened July 18, 1855. — p. 557.

Twentieth Stage. Pl. 16, fig. 6, 6a, laid June 20, opened July 17, 1855. — p. 557.

Twenty-first Stage. Pl. 14, fig. 2, and 2a, laid June 22, opened July 17, 1855; fig. 3, laid June 18, opened July 25, 1855. Pl. 18, fig. 8, no date, opened August 21, 1852. Pl. 18a, fig. 6, 7, 7a, 8, and 9, laid June 18, opened July 25, 1855; fig. 10, laid June 13, opened July 17, 1855. Pl. 20, fig. 12; (see Pl. 24). Pl. 24, fig. 2, and 2a, laid June 21, opened July 31, 1855. Pl. 22, fig. 9, no date. Pl. 9c, fig. 8, 8a, 9, and 9a; (see Pl. 14, fig. 2, 2a). Pl. 19, fig. 4, 7, about 18 days old. — p. 558.

Twenty-second Stage. Pl. 24, fig. 3, and 3a, laid June 23, opened July 30, 1855. — p. 561.

Twenty-third Stage. Pl. 15, fig. 13, laid June 18, opened July 31, 1855; Pl. 24, fig. 4, laid June 12, opened July 29, 1855; fig. 11, laid June 21, opened August 8, 1855. Pl. 16, fig. 3, laid June 16, opened August 1, 1855. Pl. 18a, fig. 4, and 5; (see Pl. 24, fig. 4). — p. 561.

Twenty-fourth Stage. Pl. 14, fig. 1, laid June 23, opened July 31, 1855. Pl. 15, fig. 11, laid June 10, opened August 2, 1855; fig. 12, and 12a, laid June 10, opened August 1, 1855. Pl. 17, fig. 4, 4a, no date, opened September 17, 1855;

fig. 6, oviduct,[1] July 20, opened September 17, 1855. Pl. 16, fig. 5, no date. Pl. 21, fig. 22, 22a, 23, 24, 25, 26, and 30, no date, opened in September, 1852. Pl. 25, fig. 11, no date. Pl. 23, fig. 1, and 1a, laid June 23, opened August 22, 1855. — p. 564.

Twenty-fifth Stage. Pl. 18a, fig. 2, and 3, laid July 20, opened September 19, 1855. Pl. 17, fig. 2, laid July 20, opened September 19, 1855; fig. 3, 3a, and 7, laid June 10, opened September 18, 1855. Pl. 19, fig. 13, 13a, 13b, and 13c, laid June 12, opened August 16, 1855. Pl. 23, fig. 2, 2a, 2b, 2c, 2d, 2e, 2f, 2g, and 2h; (see Pl. 19). Pl. 18, fig. 1; (see Pl. 17, fig. 3 and 7). Pl. 24, fig. 5, laid June 23, opened August 7, 1855. Pl. 25, fig. 4, laid June 12, opened August 13, 1855. Pl. 20, fig. 2; (see Pl. 25). Wood-cut 2. — p. 565.

Twenty-sixth Stage. Pl. 15, fig. 4, 5, and 5a, laid June 18, opened September 6, 1855; fig. 6, oviduct, June 20, opened September 4, 1855; fig. 10, oviduct, July 20, opened September 19, 1855. Pl. 13, fig. 1, laid June 18, opened September 6, 1855. Pl. 16, fig. 2, 2a, and 2b, laid June 21, opened September 1, 1855. Pl. 18, fig. 9, and 9a, no date, opened August 23, 1852. Pl. 25, fig. 2, laid June 18, opened September 4, 1855; fig, 6, 6a, and 6b, laid June 12, opened August 29, 1855; fig. 8; (see Pl. 15, fig. 4, 5, 5a, and 6). Pl. 9c, fig. 3; (see Pl. 15, fig. 4). — p. 567.

Twenty-seventh Stage. Pl. 14, fig. 13, laid June 12, opened September 1, 1855. Pl. 15, fig. 7, laid June 21, opened September 21, 1855; fig. 8, and 8a, no date, opened August 22, 1852; fig. 9, no date, opened August 21, 1852. Pl. 18a, fig. 1; (see Pl. 15, fig. 7). Pl. 20, fig. 4 and 4a, laid June 18, opened September 3, 1855. Pl. 23, fig. 3, laid June 12, opened August 28, 1855. Pl. 24, fig. 10, 10a, and 10b, laid June 18, opened September 3, 1855. — p. 568.

Twenty-eighth Stage. Pl. 16, fig. 1, laid June 21, opened October 23, 1855. Pl. 25, fig. 10, (see Pl. 16,) fig. 12, no date, opened August 25, 1852. — p. 569.

Twenty-ninth Stage. Pl. 15, fig. 1 and 2, laid June 10, opened September 20; fig. 3, laid June 10, opened September 21, 1855. Pl. 18, fig. 3, no date, opened August 27, 1852. Pl. 9a, fig. 30 and 30a; (see Pl. 15, fig. 1 and 2). Pl. 19, fig. 9 to 12, no date, opened August 25, 1852; fig. 16b, 16c, 18, 18a, 19, 20, 21, 24, 25, 26, 26a, and 32, no date, opened September 6, 1852; fig. 23, no date, opened August 25, 1852. Pl. 20, fig. 1, 1a, 1b, no date, opened August 31, 1855; fig. 5, and 6, no date, opened September 2, 1852; fig. 9, 9a, 10, 11, 7, and 8, no date, opened August 28, 1852. Pl. 21, fig. 1, 2, 3, 4, 5, 6, 7, 8, and 9, no date, opened August 30, 1852; fig. 14, 14a, and 14b, no date, opened September 9, 1852; fig. 14c to

[1] Oviduct, means that the eggs were taken from the oviduct at the time indicated; but many of these eggs were raised with those laid in the natural way, and sometimes not opened until long afterwards.

14g, 15, 15a, 34, 34a, 16, 16a, and 16b, no date, opened August 30, 1852; fig. 20 to 20d, 21, and 21a, no date, opened August 25, 1852; fig. 29 and 31, no date, opened in August, 1852; fig. 32 to 32d, no date, opened September 9, 1852. Pl. 24, fig. 6, no date, opened September 2, 1852. Pl. 25, fig. 1 to 1d, no date, opened August 30, 1852; fig. 5, no date, opened August 31, 1852.—p. 570.

Thirtieth Stage. All just hatched or hatching. Pl. 18, fig. 2, 4, and 4a, no date; fig. 10, 10b, and 10c, no date, opened August 31, 1855; fig. 10a, 10d, 10e, and 10f, no date, opened September 5, 1855. Pl. 25, fig. 3, 3a, 7, and 7a, no date; fig. 9; (see Pl. 18, fig. 10d). Pl. 19, fig. 27 and 27a, laid June 21, opened October 19, 1855; fig. 29, 29a, 30, 31, and 33, no date; fig. 34, laid June 21, opened October 17, 1855; fig. 35, and 35a, see Explanation of Plates. Pl. 20, fig. 18, laid June 21, opened October 17, 1855. Pl. 22, fig. 5, 6, 6a, and 6b, no date. Pl. 9e, fig. 11 and 11a, no date. Pl. 9a, fig. 31 and 31a, laid June 21, opened October 25, 1855.—p. 572.

Thirty-first Stage. All hatched in October, 1855. Pl. 17, fig. 1, no date. Pl. 19, fig. 14, 15, 16, 16a, and 17 to 17b, no date. Pl. 20, fig. 3, 13, 13a, 14, 14a, 15, 16, and 17, no date. Pl. 21, fig. 10, 11, 12, 13, 13a, 17, 18, 18a, 18b, 18c, 19, 33, and 33a, no date. Pl. 22, fig. 1, 1a, 1b, 2, 3, 3a, 4, 4a, 8, and 8a, no date. Pl. 23, fig. 4, 4a, 5, 6, 7, 8, 9, 10, and 11, no date. Pl. 9e, fig. 12, no date.—p. 575.

A careful preliminary comparison of these references with the Explanation of the Plates will greatly facilitate the reading of the text.

EXPLANATION OF THE PLATES.

[Diam. stands for diameters, and the figures for the number of diameters any object is magnified; i. e., 500 diam. after fig. 1, Pl. 8, means that all the objects represented in that figure are magnified 500 times their natural diameter, etc.]

PLATE I.–VIIa.

[All the figures of these Plates were drawn from nature, by A. Sonrel.]

These Plates require no special explanation. Pl. 1 to 6 represent young Turtles in their natural size at the time of hatching, or soon afterwards. Most of them are represented from three sides, in profile, from above and from below; and frequently a front view of the head, and occasionally of the whole animal, is added. The attitudes are all natural, and in most cases copied from the living animal. Pl. 6, fig. 10–12 represent an embryo of Ozotheca odorata from the middle period of incubation; fig. 17, a transverse section of the body of a young Thalassochelys Caouana; *e*, is the spinal marrow; *ld*, the neural arch; *l'*, the lungs; *t*, the windpipe; *mp*, the pectoral muscle; *r*, the liver; *h'*, the aorta; *n'*, the œsophagus; *ms*, the shoulder muscles; *rc*, the body of the vertebra; fig. 18–32, a series of embryos of Thalassochelys Caouana; fig. 30–32, a week old; fig. 28, and 29, two weeks old; fig. 26, and 27, three weeks old; fig. 24, and 25, four weeks old; fig. 22, and 23, five weeks old; fig. 20, and 21, six weeks old: fig. 18, and 19, seven weeks old. Pl. 7, and 7a, represent the mature eggs of many species, with fragments of the shell magnified.

PLATE VIII.

[All the figures of this Plate were drawn from nature, by H. J. Clark.]

Fig. 1, *a*, *b*, *c*, *c'*, *d*, *e*, *f*, *g*, *h*, *i*, *j*, *k*, *l*, *m*, *n*, *o*, *p*. Ovarian eggs of Chrysemys picta. All except c, 500 diam., and c, 1100 diameters.

Fig. 1, *h'*, *o'*. Two Graafian follicles of Ch. picta, containing each an egg, 500 diam.

Fig. 2, 3, 3a, 4, 6, 6a, 7, 8, 8a, 9a, 10. Ovarian eggs of Ch. picta; fig. 8, 25 diam.; the others, 500 diam.

Fig. 5. Graafian follicle inclosing an egg of Ch. picta; 500 diam.

Fig. 9. Same as fig. 5. Ch. picta, and Nanemys guttata; 500 diam.

Fig. 11. Ovarian egg of Ch. picta, 25 diam.; fig. 11b, the same as fig. 11, natural size; fig. 11a, the same, 500 diam.; *a*, its yolk granules, 1100 diam.

Fig. 12. Graafian follicle inclosing an egg of Ch. picta, 300 diam.; *a*, stroma; *b*, tunica granulosa; *c*, zona pellucida; *d*, embryonal membrane; *e*, *f*, the yolk.

Fig. 13, and 13a. Ovarian eggs of Ch. picta, and Nanemys guttata; fig. 13, 25 diam.; fig. 13a, 500 diam.

Fig. 14. Graafian follicle and egg, 25 diam.; fig. 14a, Purkinjean vesicle of the same, 500 diam.

Fig. 15. Ovarian egg of Ch. picta, 500 diam. Fig. 15a, *a*, *b*, *c*, *d*, *e*, *f*, *f'*, mesoblasts of the Purkinjean vesicle; *a* to *f*, 1100 diam.; *f'*, the same as *f* on an exaggerated scale.

Fig. 16. Ovarian egg, 25 diam.; fig. 16a, the same, 40 diam.; fig. 16b, albuminous globule of fig. 16a, 500 diam. Ch. picta.

Fig. 17, 17a. Ovarian eggs, 25 diam.; fig. 17b, yolk granules of fig. 17, 500 diam.; fig. 17c, same as fig. 17, natural size. Ch. picta, and Nanemys guttata.

Fig. 18. Ovarian egg, nat. size; fig. 18a, the same, 25 diam.: fig. 18b, yolk of the same, 500 diam. Ch. picta.

Fig. 19. Ovarian egg, 25 diam.; fig. 19a, the yolk, 500 diam.; fig. 19b, the egg, natural size. Ch. picta.

Fig. 20. Ovarian egg, natural size; fig. 20a, its yolk, 500 diam. Ch. picta.

Fig. 21. Ovarian egg, natural size; fig. 21a, its yolk, 500 diam. Ch. picta.

Fig. 22. Ovarian egg; *a*, natural size; *b*, the finer yolk, 500 diam.; *c*, one of the large yolk cells, 500 diam.; *d*, the same, 1100 diam.; *e*, Purkinjean vesicle, 500 diam. Ch. picta.

Fig. 23. Ovarian egg, natural size; fig. 23a, granular yolk, 500 diam.; fig. 23b, *a*, yolk cell, 500 diam.; *b*, the same, 1100 diam.; fig. 23c, *a*, yolk cell, 500 diam.; *b*, the same, 1100 diam.; fig. 23d, yolk cells, 500 diam.; *a*, *b*, angular mesoblasts. Ch. picta.

Fig. 24. Egg, natural size; fig. 24a, granular yolk, 500 diam.; fig. 24b, the Purkinjean vesicle, 500 diam.; *a*, *a*, altered mesoblasts. Nanomys guttata.

Fig. 25. Egg, natural size; *a*, *b*, *c*, *d*, *e*, its yolk cells, 500 diam. Ch. picta.

PLATE IX.

[From nature, by H. J. Clark.]

Fig. 1. Ovarian egg, natural size; fig. 1a, the same, 25 diam.; *a*, zona pellucida; *b*, Purkinjean vesicle. Ch. picta.

Fig. 2. Egg, natural size; fig. 2a, *a*, *b*, *c*, *d*, yolk cells, 500 diam. Ch. picta.

Fig. 3. Egg, natural size; fig. 3a, *a*, *b*, *c*, *d*, *e*, *g*, yolk cells, 500 diam. Ch. picta.

Fig. 4. Egg, nat. size; fig. 4a, its Purkinjean vesicle, 500 diam.; fig. 4b, the same as fig. 4a, burst open by water, 500 diam. Nanemys guttata.

Fig. 5. Egg, nat. size; fig. 5a, Purkinjean vesicle, 40 diam.; fig. 5b, another view of the same as fig. 5a; fig. 5c, the same as fig. 5a, and fig. 5b, 500 diam.; *a*, its granular contents; *b*, yolk granules.[1]

Fig. 6. Egg, nat. size; fig. 6a, *a* to *r*, yolk cells, 500 diam.; fig. 6b, yolk cells, near the Purkinjean vesicle, 500 diam. Ch. picta.

Fig. 7. Egg, nat. size; fig. 7a, Purkinjean vesicle, 40 diam.; fig. 7b, contents of the vesicle, 500 diam.; fig. 7c, 7d, 7e, 7f, 7g, yolk cells acted upon by water, 500 diam. Ch. picta.

Fig. 8. Egg, nat. size; fig. 8a, A to N, yolk cells; J, K, K′, L, L′, 1100 diam., the others, 500 diam. In all the figures, *a* is the ectoblast, *b* the mesoblast, *c* the entoblast. Ch. picta.

Fig. 9. Egg, nat. size; fig. 9a, Purkinjean vesicle, 40 diam.; fig. 9b, another view of the same; fig. 9c, the same as fig. 9a, 500 diam.;[2] *a*, *b*, granular contents. Ch. picta.

Fig. 10. Egg, nat. size; fig. 10a, Purkinjean vesicle, 40 diam.; fig. 10b, another view of fig. 10a; fig. 10c, the same as fig. 10a; *a*, *b*, granular contents, 500 diam.[3] Ch. picta.

Fig. 11. Egg, nat. size; fig. 11a, Purkinjean vesicle, 40 diam.; fig. 11b, the same as fig. 11a, 500 diam.; *a*, *b*, its granular contents; fig. 11c, yolk cells around the Purkinjean vesicle, 500 diam.; fig. 11d, the same as fig. 11c; fig. 11e, yolk cells, $\frac{1}{16}$ of an inch below the Purkinjean vesicle, 500 diam.; fig. 11f, yolk cells, $\frac{1}{8}$ of an inch below the Purkinjean vesicle; fig. 11g, yolk cells, from the centre of the egg, 500 diam.; fig. 11f, yolk cells pressing against each other, 500 diam.[4] Ch. picta.

Fig. 12, *a*, *b*, *c*, *e*, *f*; mesoblasts, altered by water, of yolk cells of an egg from the oviduct that had its shell; *d*, *d′*, pieces of the walls of the mesoblast. Ch. picta.

PLATE IXa.

[Fig. 32, 32a, from nature, by A. Sonrel, the others by H. J. Clark.]

Fig. 1. Yolk cells from an egg in the oviduct, 500 diam. Chrysemys picta.

Fig. 2, 2a, 2d. Yolk cells, 500 diam., from an egg laid June 12, opened June 26, 1852. Nanemys guttata.

Fig. 3. Yolk cells from the germinal layer, 500 diam. Egg laid June 15, opened June 16, 1854. Chelydra serpentina.

Fig. 4. Yolk cells from the germinal layer. See fig. 2, 2a, 2d, for their age.[5]

Fig. 5. Heaps of mesoblasts in the germinal layer, 250 diam.; fig. 5a, one of these heaps, 500 diam. For age, see fig. 2, etc.

---

[1] Some of the yolk granules which surround this Purkinjean vesicle are drawn upon its edge, between the outline and fig. 5.

[2] One half only of this Purkinjean vesicle is drawn; its outline passes by fig. 9c, and its contents are represented on the right side, along the frame of the Plate.

[3] Here also the outline of one half only of the vesicle is drawn, passing by fig. 10c, and the contents on the right along the frame of the Plate.

[4] The yolk cells, fig. 11d to 11h, scattered over the Purkinjean vesicle, fig. 11h, in order to save room, are, of course, out of place there, but those on its edge, fig. 11c, are in place.

[5] This, and similar references to other figures, are intended to point out the connection between the different objects represented.

Fig. 6. Heaps of mesoblasts, lower side of embryonic disc, 250 diam. For age, see fig. 2.

Fig. 7. Yolk cells from the lower side of the embryonic disc; *a*, *b*, mesoblasts; fig. 7a, the same as fig. 7, burst by water; 500 diam. From the oviduct.

Fig. 8. Mesoblasts on the upper surface of the embryonic disc, 500 diam. For age, see fig. 2.

Fig. 9, *a*, *b*. Yolk cells from the lower surface of the embryonic disc; *a'*, the mesoblast, acted upon by water; 500 diam.; *a''*, the same as *a'*, 1100 diam. From the oviduct. Chrysemys picta.

Fig. 10, and 11. Graafian follicles, 500 diam. Ch. picta.

Fig. 12. Ovarian egg, nat. size; fig. 12a, cells of the zona pellucida; 500 diam.; fig. 12b, cells of the tunica granulosa, 800 diam. Ch. picta.

Fig. 13. Piece of the Graafian follicle (see Pl. 8, fig. 12); fig. 13a, surface view of the polygonal cells of the tunica granulosa; 300 diam.

Fig. 14. Piece of the tunica granulosa, and stroma (*a*) of the Graafian follicle; fig. 14a, tunica, surface view; 500 diam. Ch. picta.

Fig. 15. Embryonal membrane from an ovarian egg (see fig. 16).

Fig. 16. Ovarian egg, nat. size; the Purkinjean vesicle appears like a black dot. Fig. 16a, portion of the Graafian follicle around fig. 16; *a*, stroma; *b*, tunica granulosa; *c*, zona pellucida; *d*, yolk; 500 diam. Chrysemys picta, and Nanemys guttata.

Fig. 17. Portion of Graafian follicle inclosing an egg; *a*, the yolk; *b*, zona pellucida; *c*, tunica granulosa; *d*, stroma; 500 diam. Ch. picta, and N. guttata.

Fig. 18. Ovarian egg, nat. size; fig. 18a, portion of the Graafian follicle; *a*, stroma; *b*, tunica granulosa; *c*, vitelline sac; *d*, yolk; *e*, zona pellucida; 500 diam. Ch. picta.

Fig. 19. Piece of the zona pellucida, 500 diam. From an ovarian egg (see fig. 20). Ch. picta.

Fig. 20. Ovarian egg, nat. size; fig. 20a, *a*, *b*, embryonal membrane, 500 diam. Ch. picta.

Fig. 21. Ovarian egg, nat. size; fig. 21a, its embryonal membrane, 500 diam. Glyptemys insculpta.

Fig. 22, and 22a. Embryonal membrane from a full-grown ovarian egg, 500 diam. Chrysemys picta.

Fig. 23. Embryonal membrane. For age, see Pl. 11, fig. 3. Chelydra serpentina.

Fig. 24. Embryonal membrane, 500 diam.; fig. 24a, the same as fig. 24, 1100 diam. For age, see Pl. 11, fig. 1. Chrysemys picta.

Fig. 25. Embryonal membrane, 500 diam. For age, see Pl. 11, fig. 2. Ch. picta.

Fig. 26. Embryonal membrane, 500 diam. From the oviduct. For age, see Pl. 11, fig. 2. Ch. picta.

Fig. 27. Embryonal membrane, 500 diam.; the egg had been laid about 18 days.

Fig. 28. Amnios, 500 diam. For age, see Pl. 12, fig. 6.

Fig. 29. Embryonal membrane, surface view; fig. 29a, profile; *a*, yolk; *b*, cells of the embryonal membrane; 500 diam. Chelydra serpentina. For age, see fig. 25, and Pl. 11, fig. 2.

Fig. 30. The allantois, inner surface; fig. 30a, outer surface; *a*, cells of the inner surface; 500 diam. Chelydra serpentina. For age, see Pl. 15, fig. 1, 2, 3.

Fig. 31. The embryonal membrane, (*a*,) the amnios, (*b*,) and the allantois (*c*) of an egg from which the young turtle is about hatching; fig. 31a, a single cell of each of these membranes; view from the outside of the egg; 500 diam. Chelydra serpentina. Laid June 21, opened Oct. 25, 1855.

Fig 32. A full-grown ovarian egg of Cistudo virginea, 3 diam.; to show the convergence of the bloodvessels around a central area and the Purkinjean vesicle on the left of it; fig. 32a, the Purkinjean vesicle as seen at the surface of the mature egg, 5 diam.

Fig 33. Yolk cell, and its segmenting mesoblast; fig. 33a, yolk cell almost filled by its mesoblast; fig. 33b, yolk cell filled by its mesoblast; 500 diam. From the oviduct; Aug. 7, 1856. Cinosternum pennsylvanicum.

Fig. 34. Germinal layer; *a*, the outer surface; *b*, underside; 500 diam. Chelydra serpentina. For age, see Pl. 11, fig. 3. An alcoholic preparation.

Fig. 35. Surface of the embryonic area; fig. 35a, germinal layer; 500 diam. From the oviduct; the egg had just commenced to segment; see Pl. 10, fig. 1, and 2; an alcoholic preparation. Glyptemys insculpta.

Fig. 36, 36a, 36b, 36c. Yolk cells from close beneath the segmenting embryonic area (see Pl. 10, fig. 1, and 2). Fig. 37, 37a, 37b, 37c, 37d, yolk cells from the side of the same egg; 500 diam.; from the oviduct. Glyptemys insculpta. Fig. 38, 38a, 38b, 38c, 39, 39a, 39b, 39c, 39d, yolk cells; 500 diam. Ozotheca odorata, laid and opened Aug. 4, 1852. Fig. 40, 40a, 40b, 40c, 40d, 40e, 40f, 40g, 40h, 40i, 40j, 40k, 40l, yolk cells of Chelydra serpentina, laid June 20, opened Aug. 20, 1856; 500 diam. In all the figures from 36 to 40l, *a* is the ectoblast, *b* the mesoblast, *c* the entoblast.

Fig. 41. Profile, and fig. 41a, view from above, nat. size of an egg of Ozotheca odorata. Laid and opened Aug. 4, 1852.

Fig. 42. Surface of egg-shell, 40 diam.; fig. 43, section of the thickness of the egg-shell and its membrane; *a*, *a'*,

calcareous nodules; *b*, base of the same; *c*, *d*, shell membrane; 500 diam.; fig. 43a, a nodule seen from the outside, 500 diam.; fig. 43b, piece of a nodule in profile, 500 diam.; fig. 43c, organic matrix of nodule, the lime dissolved out; *a*, its surface; *b*, its base; 500 diam.; fig. 44, rows of nodules of a partially formed shell, 20 diam.; fig. 44a, heaps of young nodules, 500 diam.; fig. 45, inner surface of shell membrane, 500 diam. Chelydra serpentina.

Fig. 46. Openings in the egg-shell of Ozotheca odorata, 20 diam.

PLATE IXb.

[Figs. 9, 9a, and 10, from nature, by A. Sonrel; the other figures by H. J. Clark.]

Fig. 1. Egg of Nanemys guttata, nat. size, from above; from the oviduct; for age, see Pl. 11, fig. 3.

Fig. 1a. Egg of Nanemys guttata, nat. size, from above; from the oviduct, June 3d, 1854; for age, see Pl. 10, fig. 12, 13, 14, 15.

Fig. 2. Profile, and fig. 2a, from above. Chrysemys picta, nat. size; from the oviduct, June 3d, 1852; for embryo, see Pl. 11, fig. 2.

Fig. 3. Profile of an egg of Cinosternum pennsylvanicum, nat. size; from the oviduct, July 3d, 1856. Alcoholic preparation. Fig. 3a, one of the layers of albumen; *a*, the surfaces in profile; *b*, the interior; 25 diameters.

Fig. 4. Profile, and fig. 4a, from above; nat. size; from the oviduct, June 2d, 1854. Glyptemys insculpta. Alcoholic preparation; for embryo, see Pl. 11, fig. 6.

Fig. 4b. View from above of an egg without a shell, nat. size; from the oviduct. Glyptemys insculpta. Alcoholic preparation.

Fig. 5. Profile of the egg of Chelydra serpentina, nat. size; from the oviduct, June 12, 1854.

Fig. 6. Egg of Platypeltis ferox; from the oviduct, Aug. 20, 1856; nat. size. Alcoholic preparation. Fig. 6a, portion of a layer of albumen; *a*, surfaces in profile; *b*, the interior; 20 diam. Fig. 6b, albumen from the deeper layers; *a*, *b*, *c*, the oval granules, trending in three different directions; 500 diam. Fig. 6c, inner layer of shell membrane; *a*, *b*, the oval, elongated granules, trending in two different directions; 500 diam. Fig. 6d, shell membrane, just outside of the inner layer (fig. 6c); *a*, granules in strings; *b*, finer granular strings; 500 diam. Fig. 6e, *a*, *b*, *c*, three layers from the middle of the thickness of the shell membrane; 500 diam. Fig. 6f, from the middle of the membrane; *a*, separate granules; *b*, fine fibres; 500 diam. Fig. 6g, shell membrane next to the shell, 500 diam.

Fig. 7. Profile and fig. 7a, from above; nat. size; just laid, date lost. Thalassochelys Caouana. Alcoholic preparations.

Fig. 8. From above; nat. size; one week since laid; the same species as fig. 7.

In all the figures of these eggs, from fig. 1 to fig. 8, *a* designates the albumen outside of the yolk sac, a^1 the albumen inside of the yolk sac, *s* the shell, *y* the yolk, y^1 the surface of the yolk, *e* the embryonic disc, *va* the vascular area.

Fig. 9. Portion of the oviduct containing an egg, nat. size; *ma*, its mesenteric peritoneum; fig. 9a, slightly magnified portion of the oviduct to show the numerous bloodvessels, and the pigment following their courses. Glyptemys insculpta.

Fig. 10. The left ovary and oviduct, from below, nat. size; *or*, or^1, the oviduct; or^2, its posterior end; *p*, the pavilion, or anterior opening; *pr*, ramifications of pigment cells; *bl*, the urinary bladder. Chrysemys picta.

Fig. 11. Right ovary and oviduct, seen from below, nat. size; *i*, the intestine; *cl*, the corpora lutea, or cicatrices; *m*, the mesenteric peritoneum of the oviduct; *p*, the pavilion; *e*, *e*, *e*, *e*, four eggs covered by the oviduct. Glyptemys insculpta; opened May 20, 1854.

PLATE IXc.

[Figs. 1, 2, 3, from nature, by H. J. Clark, the others by A. Sonrel.]

Fig. 1. The same as Pl. 8, fig. 12, on a larger scale. *a*, a^1, the two layers of the stroma; *b*, tunica granulosa; *c*, zona pellucida; *d*, embryonal membrane; d^1, profile of *d*; *vs*, yolk sac; *e*, outer layer of fine yolk granules; *f*, inner layer of coarse yolk granules; *g*, Purkinjean vesicle.

Fig. 2. Diagramic profile of an egg after the albumen has become partially absorbed. The same as Pl. 11, fig. 4, 4a. *a*, the shell; *b*, shell membrane; b', albumen; b'', innermost and densest layer of albumen; *c*, zona pellucida; *d*, embryonal membrane; *e*, germinal layer; e', embryonic disc; *j*, surface of the yolk; *al*, albumen within the yolk sac.

Fig. 3. Actual view of the interior of the embryo and its envelopes, seen from the front, to show the relations of the vascular system. The red color corresponds to the ventricle (*p*) and the arterial system of the body and yolk; the blue to the auricles (*r*) and the venous system of the body and yolk; the yellow to the arterial system

of the allantois; the green to the venous system of the allantois. *a*, the shell; *b*, shell membrane; *c*, zona pellucida (see p. 485); *d*, embryonal membrane; *e*, outer peripheric portion of the amnios (see p. 541); *f*, *h*, *m*, *l*, the allantois; *m*, *m*, edges of its superior folds; *h*, its lower border; *l*, its peduncular base; —·—·—·, its posterior portion next to the yolk on the right side; *k*, *k'*, amnios; (*k*,) its umbilicus; . . . . embryonal membrane lining the amniotic sac, (*k*, *k'*.) and covering the shield of the embryo, here represented by a transverse, triangular section; *g*, vascular area; *i*, its lower border; *i'*, subsidiary layer, in which run the omphalo-meseraic arteries (*q'*); *j*, yolk; *n*, intestine; *o*, allantoidian arteries; *o'*, the same passing close to the body, and then more outwardly; *p*, ventricle with aorta (darker red) in the middle; *p'*, branchial arteries; *p''*, dorsal artery foreshortened; *p''* to *q*, single omphalo-meseraic artery passing down behind the heart (*p*, *r*); *q*, two branches of the same; q^1, omphalo-meseraic arteries of the yolk, which anastomoze with the veins at *i*; *r*, the double ventricle; *r'*, omphalo-meseraic veins ramifying through the mass of the yolk; *s*, abdominal veins foreshortened, in part, and turned in to enter the auricles (*r*); *t*, allantoidian veins, foreshortened in part, which run along the sides of the body, and pass in behind, and into the ventricle (*r*); *t'*, allantoidian veins, which run on the outer folds; *t''*, the same as *t'*, running along the inner folds, close against the body, and then on the outer folds. Chelydra serpentina, about 4 diam., corresponds to Pl. 15, fig. 4, 5, 5a, and to Pl. 16, fig. 2, 2a, 2b.

Fig. 9, 10, 11, 12, 15, 16, 17, 13, 14, 4, 5, and 6 represent a series of embryos of Chelydra serpentina, from the time the shield begins to be distinct to the moment of hatching. Fig. 6 represents a young just breaking through the egg-shell. All in their natural size.

Fig. 7, and 8. Ozotheca odorata; fig. 7, head from below; fig. 8, young breaking through the egg-shell; nat. size.

Fig. 22, 23, 18, 19, 20, and 21, represent a series of embryos of Chrysemys picta; nat. size.

PLATE IXd.

[Drawn by H. J. Clark.]

Fig. 1. An actual longitudinal section of an embryo, 40 diam. The embryo is nearer to the yolk (*yk*) than is natural. The two opposite sides of the lateral halves of the yolk are approximated here for want of room, but the level of the vitelline surface is kept in its proper relation to the position of the embryo. *a*, a^1, a^2, a^3, a^4, the amnios; *a*, its peripheric part; a^1, a^2 above, the edge of its dorsal aperture; a^2 at the tail, to a^3 above, the caudal hood; a^2, a^3, a^1, the cephalic hood; a^3, a^4, the area pellucida of the subsidiary layer (*n*, o^1); *c*, *c*, the area pellucida; *d*, *d*, its periphery; *e*, e^1, e^2, e^3, e^4, e^5, spinal marrow; *e*, edge of the channel of the spinal marrow; e^1, floor of the same; e^1, e^2, edge of the broad channel of the brain; e^3, point where the edges touch; e^4, lower floor of the brain; e^4, posterior end of the germino-spinal layer; f^1, vertebral layer; *f*, vertebræ; *g*, anterior end of the chorda dorsalis; g^1, its posterior end; *h*, heart; i^1, incipient vena terminalis; j^2, cavity between the vertebræ (f^1) and the subsidiary (*n*) layer; *n*, intestino-subsidiary layer; o^1, peripheric part of the subsidiary layer; —·—·—, point where the lower half of the egg joins the segment of the upper part; *yk*, the yolk (its cells are magnified just as much as the embryo); *al*, albumen; *vs*, yolk sac, or rather zona pellucida; . . . ., embryonal membrane. Chelydra serpentina; the same as Pl. 12, fig. 1, 1a.

Fig. 2. An actual section of the walls of the Graafian follicle, and of a full-grown egg, 500 diam. *a*, a^1, the two walls of the stroma; *b*, tunica granulosa; *c*, zona pellucida; *vs*, vitelline or yolk sac; *d'*, embryonal membrane; *e*, yolk cells about the Purkinjean vesicle (*g*); *ec*, yolk cells from the centre of the yolk. Chrysemys picta. Compare fig. 11b, Pl. 9.

Fig. 3. View from above of fig. 2, Pl. 9c; the letters are the same.

Fig. 4. Profile of an egg of Ozotheca odorata, nat. size; the shell broken open at the side to expose the yolk; *e*, embryonic disc.

Fig. 5. The albumen of a hen's egg, at the point where resorption is going on, showing the exposed edges of all the layers of albumen, down to the yolk.

PLATE IXe.

[Drawn by H. J. Clark.]

Fig. 1 to fig. 9a are longitudinal and transverse sections of the embryo. The same parts are lettered alike in all; . . . ., embryonal membrane; *al*, albumen; *yk*, yolk; *a*, germinal layer; a^1, fold of the cephalic hood; a^2, fold of the caudal hood; a^3, the subsidiary layer in the area pellucida about the head; a^4, the same about the tail; a^5, cephalic hood; a^6, base of attachment of the cephalic hood; *b*, primitive furrow; *c*, area pellucida; c^1, cavity between the germino-amniotic (*a*) and subsidiary (o^1) layers in the area pellucida; *d*, periphery of the area pellucida; *e*, edge of the primitive furrow, or of the spinal channel; e^1, cephalic region of the spinal nervous system; e^3, spinal marrow closed over; e^4, caudal portion of the same; e^7, lower floor of the spinal canal; *f*, vertebræ; f^1, vertebral layer; f^3, lower edge of the vertebræ; f^4, upper edge; f^6, outer or lateral limit of the vertebræ; *g*, chorda dorsalis; i^1, incipient vena terminalis; j^3, dorsal artery; *n*, intestino-subsidiary layer; n^3, stomach; n^4, œsophagus; n^8, mesenterium of the intestine; o^1, subsidiary layer; *p*, musculo-cutaneous layer; p^1, musculo-costal layer; *q*, Wolffian bodies; q^1, their ducts; *r*, liver; *w*, the feet.

Fig. 1 corresponds to Pl. 10, fig. 12, 13, 14, 15. An ideal section.

Fig. 2 corresponds to Pl. 11, fig. 1, 6, 6a; 25 diam. An actual longitudinal section.

Fig. 3 corresponds to Pl. 11, fig. 3. Ideal longitudinal section. Fig. 3a, ideal transverse section of fig. 3.

Fig. 4 corresponds to Pl. 11, fig. 5, 5a. Ideal longitudinal section. Fig. 4a, ideal transverse section of fig. 4, through the point e^7. Fig. 4b, another transverse section through the point *h*, so as to include the upper and lower bend of the body.

Fig. 5 corresponds to Pl. 12, fig. 1, 1a. An ideal transverse section at about midway between head and tail. (In this figure, the dots from the letter *e*, on the right, should extend to the next inner line, which runs close to f^4.)

Fig. 6. An actual transverse section close behind a^1, fig. 2, Pl. 12; 40 diam.

Fig. 7 corresponds to Pl. 18, fig. 7. Actual transverse section, near the posterior end of the body.

Fig. 8 corresponds to Pl. 14, fig. 2, 2a. Actual transverse section of the embryo of Thalassochelys Caouana, just behind the fore legs, about 5 diam.

Fig. 8a. The same as fig. 8. Actual transverse section through the middle region of the body.

Fig. 9. The same as fig. 8, 8a. Actual transverse section just behind the opening of the œsophagus. Nanemys guttata, 12 diam.

Fig. 9a. The same as fig. 8 and 9. Actual section across the root of the tail, 12 diam.

Fig. 10 to 10d. Spermatic particles from the testicle of an adult turtle. Chrysemys picta; fig. 10, 10a, 500 diam.; fig. 10b shows the swelling (a^1) at the base of the so-called head (*a*); *b*, the tail; fig. 10c, another view of 10b, showing that the swelling (a^1) is on one side. The origin of this swelling has not been traced in turtles; but, from its similarity to what has been seen in several other animals, we have no hesitation in pronouncing it to be the remains of the cell in which the particle was developed; fig. 10d, a perfectly mature particle, the most numerous and lively of all, free from the remains of the parent cell; figs. 10b, 10c, 10d, 1100 diam.; April 8, 1856.

Fig. 11. Longitudinal section of the right branches of the lower jaw; *a*, channel of the nerve; *b*, lateral cavities connecting with *a*; *d*, teeth of the suture; fig. 11a, transverse section of fig. 11; the letters *a*, *b*, the same; c, cartilaginous strip in the sulcus inframaxillaris; •-----•, line through which the longitudinal section was made. About 12 diam. Chelydra serpentina, just ready to be hatched.

Fig. 12. Transverse section of a rib and of the shield, 40 diam.; *a*, *a'*, cartilaginous part of the rib; *b*, its wings; *c*, the corium; *c'*, corium below the rib; *d*, fibrous lining of the shield; *e*, epidermis. Chelydra serpentina, just hatched.

PLATE X.

[Fig. 2, 3, 4, 12, 13, 14, from nature, by H. J. Clark; the others by A. Sonrel. Excepting fig. 12, 13, 14, all were taken from the oviduct of Glyptemys insculpta.]

In all the figures, *a* marks the region immediately around the embryonic area; a^1, the "cones;" *b*, the space where segmentation is going on; c, the yolk; *d*, the albumen; *e*, the segment masses beyond the embryonic disc.

Fig. 1. The whole egg, the shell being removed, 3 diam., seen from above; fig. 1a, the same, nat. size. This was the anterior or first egg in the left oviduct.

Fig. 2. Deeper view of fig. 1.

Fig. 3. Anterior or first egg in the right oviduct.

Fig. 4. Second egg in the right oviduct.

Fig. 5. Third egg in the right oviduct.

Fig. 6. Third egg in the left oviduct.

Fig. 7. Second egg in the left oviduct.

Fig. 8. Fourth egg in the left oviduct.

All the eggs represented in fig. 1 to 8 were taken from the same turtle, May 27, 1854.

Fig. 9. Fourth egg in the right oviduct.

Fig. 10. Second egg in the left oviduct.

Fig. 11. First egg in the right oviduct, 25 diam.

Fig. 11a. The whole egg, without the shell, nat. size. The same as fig. 11.

Fig. 11b. The same as fig. 11. The whole egg, 3 diam.

All the eggs represented in fig. 9 to 11b were taken from one turtle, May 28, 1854.

Fig. 12. Embryonic disc, about 5 diam. Nanemys guttata; from the oviduct, June 4, 1852.

Fig. 13. The same as fig. 12; from the oviduct, June 3, 1852.

Fig. 14. Embryonic disc, 12 diam.; from the oviduct, June 3, 1852. Chrysemys picta.

Fig. 15. Embryonic disc, about 3 diam.; from the oviduct, May 29, 1854. Glyptemys insculpta. Fig. 15a, the same as fig. 15; the yolk, seen from above, nat. size.

PLATE XI.

[Fig. 1, 1a, 2, 3, 3a, 4, 4a, 4b, 5, 5b, 5c, from nature, by A. Sonrel; fig. 5a, 6, 6a, 7, 7a, 7b, 8, 9, 9a, 9b, 10, 10a, 10b, 10c, by H. J. Clark.]

In all the figures, *a* is the region about the embryonic disc; a^1, the cephalic hood; a^2, the caudal hood; a^3, a^4, see Pl. 9c, fig. 4, 4a, 4b, a^3, a^4; a^5, the end of the head; *b*, the primitive furrow; *c*, the area pellucida; *d*, the area vasculosa.

Fig. 1. Embryo of Chelydra serpentina, 20 diam.; fig. 1a, the same as fig. 1, yolk and inner layer of albumen in profile, nat. size. Laid June 21; opened June 26, 1855.

Fig. 2. Embryo of Chelydra serpentina, 20 diam.; period of laying unknown; opened June 16, 1854.

Fig. 3. Ch. serpentina, 20 diam.; period of laying unknown, opened June 12, 1854 (in this figure, *a* should be *d*, as in fig. 2); fig. 3a, the same as fig. 3, yolk and inner layer of albumen in profile, nat. size.

Fig. 4. Ch. serpentina, 20 diam.; period of laying unknown, opened June 12, 1854. Fig. 4a profile, and 4b from above, yolk and inner layer of albumen, nat. size.

Fig. 5. Ch. serpentina, from above, fig. 5a from below; 20 diam.; laid June 23, 1855, at 9½ o'clock, A. M.; fig. 5 opened June 26, 1855, at 4 P. M., fig. 5a opened about 9 A. M., June 27, 1855; fig. 5b, profile of the whole egg of fig. 5 and 5a, nat. size; fig. 5c, the same as fig. 5b, seen as if cut through the middle to show the concave surface of the yolk, nat. size.

Fig. 6. Malacoclemmys palustris, 18 diam.; laid and opened July 3d, 1855; fig. 6a, actual longitudinal section of fig. 5; 25 diam.

Fig. 7. Malacoclemmys palustris, from above; fig. 7a, the same as fig. 7, from below; 20 diam.; fig. 7b, longitudinal section of fig. 7 and 7a, 25 diam.; laid July 2, opened July 3, 1855.

Fig. 8. Ozotheca odorata, from below; fig. 8a, anterior end of fig. 8, from above, 30 diam.; laid July 10, opened July 12, 1855.

Fig. 9. Oz. odorata, from above; fig. 9b, actual longitudinal section of fig. 9; fig. 9a, actual transverse section across the middle of fig. 9; 26 diam.; laid and opened July 4, 1855.

Fig. 10. Malacoclemmys palustris, from above; fig. 10a, from below; fig. 10b, actual longitudinal section; fig. 10c, view of fig. 10 from front; 26 diam.; laid July 2, opened July 3, 1855.

PLATE XII.

[Figs. 2, 3, 3a, 3b, 4, 5, from nature, by A. Sonrel; the others by H. J. Clark.]

In all the figures of this Plate, *a* designates the amnios; a^1, the posterior bend of the cephalic hood; a^2, the caudal hood; a^3, the point of disjunction of the subsidiary layer and of the germino-amniotic layer; a^4, the cephalic hood; a^5, the basis of the cephalic hood; *c*, the area pellucida; *d*, the area vasculosa; *e*, the spinal marrow; e^1, the upward folding borders of the brain; e^2, the edge of the open medulla oblongata; e^3, the point where the brain is closed over; e^4, the caudal portion of spinal marrow; *f*, vertebræ; f^1, the vertebral layer; *g*, the chorda dorsalis; *h*, the heart; *i*, the vena afferens; i', the vena terminalis; *j*, the branchial arteries; *k*, the eyes; *l*, the ears; *m*, the branchial fissures; *o*, the abdominal aperture, and the basis of attachment to the amnios; *p*, the musculo-cutaneous layer.

Fig. 1, from above; fig. 1a, from below; 25 diam. (In this figure, c' should be e'.) Chelydra serpentina; laid June 12, opened June 28, 1855.

Fig. 2, from above, 25 diam. Chelydra serpentina; laid June 12, opened June 26, 1855.

Fig. 3, from below, on partially darkened background; fig. 3a, the same as fig. 3, by transmitted light; fig. 3b, from above; 20 diam. Ch. serpentina; period of laying unknown, opened June 24, 1854.

Fig. 4, from below, 22 diam. Ch. serpentina; period of laying unknown, opened June 24, 1854.

Fig. 5. Three quarters view from below, 22 diam. Ch. serpentina; period of laying unknown, opened June 25, 1854.

Fig. 6. Right side and in profile, 24 diam. Nanemys guttata; period of laying unknown, opened July 28, 1852.

Fig. 7, from below, 5 diam. Nanemys guttata; period of laying unknown, opened July 28, 1852.

Fig. 8, from above and to the left, 24 diam. N. guttata; laid July 18, opened July 30, 1852.

Fig. 9, from above and to the left, 26 diam. N. guttata; laid July 16, opened July 26, 1852.

Fig. 9a, from above, the same as fig. 9.

Fig. 10, from below, 20 diam.; fig. 10a, the same as fig. 10, from above; (in this figure, a^4 should be a^1; correct also the same mistake in the text, p. 541, line 16;) fig. 10b, the same as fig. 10a, seen more from the front; fig. 10c, the same as fig. 10, seen directly from the front. N. guttata; laid July 18, opened July 27, 1852.

Fig. 11. Posterior half, from above, 20 diam. N. guttata; laid July 11, opened July 22, 1852.

Fig. 12. Posterior half, from the left side, 26 diam. N. guttata; laid July 18, opened July 29, 1852.

Fig. 13. Posterior half, from below and to the left, 25 diam. N. guttata; laid July 18, opened July 28, 1852.

PLATE XIII.

[Fig. 4 from nature, by H. J. Clark; the others by A. Sonrel.]

Fig. 1. Interior view of the egg, the shell being taken off, and the shell membrane varnished; *o*, the allantoidian vessels; *h*, the upper surface of the yolk sac; *r*, the vena afferens, 2 diam. Chelydra serpentina; laid June 18, opened Sept. 6, 1855.

Fig. 2. Embryo and vascular area, from above; the arrows indicate the direction of the currents of blood; about 6 diam. Ch. serpentina; period of laying unknown, opened Aug. 3, 1852.

Wood-cut 1, p. 553, represents parts of the same figure; *f*, vertebræ; i^3, allantoidian artery, running along the side of the body; j^3, abdominal or dorsal artery; n^4, allantois.

Fig. 3, from below, about the same diam. as fig. 2. Ch. serpentina; laid June 18, opened July 10, 1855; *q*, point from which the omphalo-meseraic arteries radiate.

Fig. 4, 5, 6, 7, 8, 9. Views in profile and from above of the egg, with the shell partially taken off, to exhibit the extent of the circulation of the blood, nat. size. Ch. serpentina; all laid June 12, and opened July 11, 1855.

Fig. 10, and 11. Laid June 18, and opened July 11, 1855. Ch. serpentina, nat. size.

Fig. 12. Laid June 18, and opened July 10, 1855. Ch. serpentina, nat. size. (See p. 599.)

PLATE XIV.

[Fig. 1, from nature, by H. J. Clark; the others by A. Sonrel.]

All the figures are of Chelydra serpentina.

Fig. 1. Embryo from the left side, about 3½ diam.; laid June 23, opened July 31, 1855.

Fig. 2. From above, about 3 diam.; the allantois nearly covers the embryo. *r*, vena afferens; r^1, vena terminalis; laid June 23, opened July 18, 1855.

Fig. 2a. From above, about 5 diam.; laid June 23, opened July 17, 1855.

Fig. 3. From below, about 5 diam.; laid June 18, opened July 25, 1855.

Fig. 4. From the right side, about 5 diam. *o*, allantoidian artery; *t*, allantoidian vein running along the side of the abdominal opening. Taken from the oviduct June 20, and opened July 18, 1855.

Fig. 5. From above, about 2½ diam.; laid June 18, opened July 17, 1855.

Fig. 6. From above, about 1½ diam.; laid June 18, opened July 10, 1855.

Fig. 7. From above, about 1½ diam.; laid June 23, opened July 10, 1855.

Fig. 8. From above, about 1½ diam.; taken from the oviduct, June 20, and opened July 10, 1855.

Fig. 9. From above, about 1½ diam.; laid June 18, opened July 10, 1855.

Fig. 10. From above, about 1½ diam.; taken from the oviduct, June 20, and opened July 10, 1855.

Fig. 11. From above, about 2 diam.; laid June 18, opened July 11, 1855.

Fig. 12. From above, about 2 diam.; period of laying unknown, opened June 25, 1854.

Fig. 13. From above, nat. size; laid June 12, opened September 1, 1855.

PLATE XV.

[Drawn from nature, by A. Sonrel.]

All the figures are of Chelydra serpentina.

Fig. 1. From the right; fig. 2, from the left side, the shell being taken off; fig. 3, the allantois and amnios cut away; nat. size; fig. 1 and 2, laid June 10, opened Sept. 20, 1855; fig. 3, laid June 10, opened Sept. 21, 1855.

Fig. 4, 5, 6. From above, nat. size; fig. 4, outer folds of the allantois cut away, leaving the inner folds with their bloodvessels running over the amnios; fig. 5, to the right the whole allantois is lifted off and cut away so as to expose the radiating vessels of the vascular area; laid June 18, opened Sept. 6, 1855; fig. 6, the allantois entire; taken from the oviduct June 20, opened Sept. 4, 1855; fig. 5a, a portion of the large vena afferens of fig. 5, and the two omphalo-meseraic arteries at the point where they begin to branch, about 5 diam.

Fig. 7. From the right side, the allantois and amnios cut away; laid June 21, opened Sept. 21, 1855.

Fig. 8. From the right side; the shell is removed; *i*, edge of the vascular area; fig. 8a, the same as fig. 8, from the left side, on the right the allantois is cut away to show the edge of the shield more distinctly, 2 diam.; period of laying unknown, opened Aug. 22, 1852.

Fig. 9. From above, the shell partially removed, 2 diam.; period of laying unknown, opened Aug. 21, 1852.

Fig. 10. Twins, nat. size; the shell is removed; taken from the oviduct, July 20, opened Sept. 19, 1855.

Fig. 11. From above, the shell mostly cut away; laid June 20, opened Aug. 2, 1855.

Fig. 12. From above, the allantois drawn back; fig. 12a, the same as fig. 12, the embryo from behind, to show the extent of the vascular area on the lower side of the yolk; laid June 10, opened Aug. 1, 1855.

Fig. 13. Embryo with its allantois, taken out of the shell, about 3 diam.; laid June 18, opened July 31, 1855.

PLATE XVI.

[Fig. 4 from nature, by H. J. Clark, the others by A. Sonrel.]

Fig. 1. The allantois and amnios removed. Chrysemys picta, nat. size. Laid June 21, opened Oct. 23, 1855.

Fig. 2. From above, the shell cut away, nat. size; fig. 2a, the same as fig. 2, from below, about 2 diam., the shell being removed to show the superficial extent of the vascular area; r^1, vena afferens; fig. 2b, the same as fig. 2, and 2a, the allantois and amnios cut away, and the embryo turned back and exposed from below; r^1, the point where the vena afferens enters the yolk mass. Chrysemys picta. Laid June 21, opened Sept. 1, 1855.

Fig. 3. From above, 5 diam.; r^1, vena afferens. Chrysemys picta. Laid June 16, opened Aug. 1, 1855.

Fig. 4. Seen obliquely from above and to the right, about 2 diam. Period of laying unknown, opened Sept. 17, 1852. Ch. picta.

Fig. 5. From above, a little more than 3 diam. The allantois is drawn back. Ch. picta. Date of laying unknown, opened Aug. 2, 1855.

Fig. 6. From above and to the right; fig. 6a, the same from the left, without the vascular area; about 4 diam. Laid June 20, opened July 17, 1855. Nanemys guttata.

PLATE XVII.

[All the figures of this Plate are drawn from specimens of Chelydra serpentina; fig. 6, by A. Sonrel, the others by H. J. Clark.]

Fig. 1. Portion of the intestine and of the adherent yolk sac, about 5 diam. The vena afferens on the right; in the middle the omphalo-meseraic artery. Hatched in October.

Fig. 2. Portion of the intestine to show its opening into the yolk sac, 5 diam. On the right the afferent vein; in the middle the omphalo-meseraic artery. Taken from the oviduct, July 20, opened Sept. 19, 1855.

Fig. 3. Portion of the vascular area, just below the surface. The large vessel on the left is an omphalo-meseraic artery, the others are omphalo-meseraic veins; the arrows indicate the course of the blood, 250 diam.; fig. 3a, large, transparent cells from fig. 3, 500 diam. Laid June 10, opened Sept. 18, 1855.

Fig. 4. Portion of the allantois, 20 diam.; fig. 4a, portion of the same as fig. 4, 40 diam. Period of laying unknown, opened Sept. 17, 1855.

Fig. 5. Part of the edge of the vascular area, 5 diam. Period of laying unknown, opened Aug. 6, 1852.

Fig. 6. Strip of the vascular area, from the first part of the omphalo-meseraic artery to the vena terminalis, 5 diam. Taken from the oviduct, July 20, opened Sept. 17, 1855.

Fig. 7. Portion of the nearly parallel omphalo-meseraic arteries, and the very crooked omphalo-meseraic veins, 5 diam. Laid June 10, opened Sept. 18, 1855.

PLATE XVIII.

[Fig. 1, 2, 3, 4, 4a, 5, 7, 9, 11, 11a, 11b, from nature, by H. J. Clark. Fig. 6, 8, 9a, 10, 10a, 10b, 10c, 10d, 10e, 10f, by A. Sonrel.]

Fig. 1. Omphalo-meseraic vein with a very thick wall, 500 diam.; the same as Pl. 17, fig. 3, and 7. Ch. serpentina.

Fig. 2. Omphalo-meseraic artery, 500 diam. Embryo just hatched.

Fig. 3. Piece of the allantois with a bloodvessel, 500 diam. Period of laying unknown, opened Aug. 27, 1852.

Fig. 4. Mesh of bloodvessels covered by yolk, 20 diam.; fig. 4a, a single vessel in its sheath of yolk, 500 diam. Ch. serpentina. Just hatched.

Fig. 5. Posterior end of the dorsal artery and the neighboring omphalo-meseraic arteries. Magnified from fig. 7. Nanemys guttata. Laid July 11, opened July 22, 1852.

Fig. 6. The fork of the vena terminalis, 12 diam.; the same as fig. 7.

Fig. 7. From below, 5 diam.; the same as fig. 5, and 6.

Fig. 8. From above, 3½ diam. Nanemys guttata. Period of laying unknown, opened Aug. 21, 1852.

Fig. 9. From above, 2 diam. Ozotheca odorata. Period of laying unknown, opened Aug. 23, 1852; fig. 9a, the same as fig. 9. The embryo and allantois drawn to one side.

Fig. 10. From the right side; fig. 10a, from above; fig. 10b, from below; fig. 10c, from the left side, the allantois partly opened; fig. 10d, the same, the allantois being cut away; fig. 10e, the same, from behind; fig. 10f, the same as 10d, 10e, from above. Cistudo virginea, nat. size. Just ready to hatch. Period of laying unknown; fig. 10, 10b, 10c, opened Aug. 31, 1855; fig. 10a, 10d, 10e, 10f, opened Sept. 5, 1855.

Fig. 11, 11a, 11b, *a*, *b*. Crystals of nitrate of lime. See p. 508, on the structure of the egg-shell.

PLATE XVIIIa.

[Fig. 1, 2, 3, from nature, by A. Sonrel, the others by H. J. Clark.]

Fig. 11, 12, 13, 14. Nanemys guttata, the others, Chelydra serpentina. Throughout the Plate the letter *a* designates the amnios; a^1, the cephalic hood; a^2, the caudal hood; e^1, the medulla oblongata; e^2, the corpora quadrigemina; e^3, the choroid plexus; *f*, the vertebræ; *h*, the heart; h^1, the aorta, or aortic bulb; h^2, the branchial aorta; h^3, the auricle; h^4, the ventricle; *i*, the vena afferens; i^1, the allantoidian vein; i^2, the abdominal vein; i^3, the junction of the allantoidian and abdominal vein; i^4, the cephalic vein; *j*, the cephalic artery; j^1, the dorsal artery; j^2, the allantoidian artery; j^3, the omphalo-meseraic artery; j^4, the junction of the abdominal or dorsal artery and the omphalo-meseraic artery; j^5, the junction of the abdominal and allantoidian arteries; *k*, the eyes; *l*, the ears; *m*, the branchial fissures; n', n^1, the intestine; n^2, the stomach; n^3, the junction of the allantois and intestine, except in fig. 5, where it refers to the œsophagus; n^4, the œsophagus; n^5, the anus; *q*, the Wolffian bodies; *r*, the liver; *t*, the windpipe; t', the lungs; *u*, the gall cyst; *v*, the nostrils.

Fig. 1. Head of Pl. 15, fig. 7, 4 diam.; j^1, cephalic arteries.

Fig. 2. Young turtle from above, 2½ diam. Taken from the oviduct, July 20, opened Sept. 19, 1855.

Fig. 3. From below, 2 diam. Laid open to expose the organs; the same as fig. 2.

Fig. 4. Wolffian body, intestine, liver, and bloodvessel dissected out; the anterior end is on the right; about 5 diam. Laid June 12, opened July 29, 1855.

Fig. 5. Heart, vessels, liver, intestine, dissected out; the anterior end is to the left; the same as fig. 4.

Fig. 6. Heart and branchial aortæ, about 10 diam. Laid June 18, opened July 25, 1855.

Fig. 7. Anterior end of fig. 8, from above; fig. 7a, posterior end of fig. 8, and 9, from below, laid open. Where the allantoidian arteries (j^2) join the abdominal artery, (j^5,) the intestine (n^1) is cut away.

Fig. 8. This figure, the largest of the Plate, is erroneously marked 2 in most copies. The same as fig. 6, 7, 7a, 9, from the right side. The Wolffian body (*q*) is drawn down a little, to expose the dorsal artery (j^1); about 10 diam.

Fig. 9. The same as fig. 8, from below, about 5 diam. Laid open before and behind, and the allantois, the amnios, and the yolk sac turned aside.

Fig. 10. Heart, and adjoining vessels, dissected out; 10 diam. Laid June 13, opened July 17, 1855.

Fig. 11. Heart, and branchial arteries from the right side; 25 diam. Laid July 14, opened Aug. 2, 1852.

Fig. 12. Heart, from the left side; the same as fig. 11.

Fig. 13. Anterior part of the body from the right side, 12 diam. Laid July 15, opened July 26, 1852. The dotted lines which should connect the letters h^3 and h^1 are unfortunately omitted; h^3 should go to the dark hole in the heart, which is nearest to the letter, and h^1 to that part of the aorta which is just below the longest branchial fissure, (*m*,) that runs from the ear (*b*) downwards. The *i* nearest to the letter h^3 should be i^1.

Fig. 14. From the left side. The amnios, (*a*,) behind the head, laid open; 12 diam. Laid July 10, opened July 20, 1852. The first letter to the left of *k* should be e^3 instead of e^1.

PLATE XIX.

[Drawn from nature, by H. J. Clark.]

Fig. 1, 2, 3, 4, 5 to 5d, 6, 7, 8, 22 are from Nanemys guttata, the others from Chelydra serpentina.

Fig. 1. Cells on the surface of the head near the eye, 300 diam. Laid July 18, opened July 28, 1852.

Fig. 2. Surface cells of the tail, 500 diam.; *c*, profile; *a*, a cell; *b*, its mesoblast. Laid July 11, opened July 22, 1852.

Fig. 3. A vertebra, 500 diam. Laid July 18, opened July 27, 1852.

Fig. 4. Transverse section across the middle region of the body, and between the vertebræ, 40 diam.; (*a*, cells from the dermal layer, (*f*,) 500 diam.); a', spinal tube; *b*, chorda dorsalis; *c*, dorsal artery; *d*, Wolffian bodies; *e*, duct of *d*; *f*, musculo-cutaneous layer; *g*, mesenterium of the intestine. About 18 days old.

Fig. 5. Surface view of the anterior end of the chorda dorsalis; *a*, cell in profile; fig. 5a, surface view near the posterior end; *a*, cell in profile; fig. 5b, middle region; *a*, view of the surface; *b*, of the interior; 500 diam.; fig.

5d, chorda, entire, 25 diam. Laid July 10, opened July 20, 1852.

Fig. 5c. Chorda, near the anterior end, 500 diam. The same as fig. 3.

Fig. 6. Blood corpuscles from the vena terminalis, 40 diam. Laid July 18, opened July 28, 1852.

Fig. 7. Blood corpuscles; *a*, *b*, in a natural state; *c* to *j*, altered by water; *a* to *i*, 500 diam.; *j*, 1100 diam. About 18 days old.

Fig. 8. Blood corpuscles from an adult; *a*, *b*, *c*, *d*, *e*, in a natural state; *h*, altered by water, and dried; the others in water; *a*, *b*, *c*, 1100 diam.; the others, 500 diam.

Fig. 9, 10, 11, 12. Blood corpuscles; fig. 9, from the yolk; fig. 10, from the allantois; *a*, *b*, end views; *c*, *c'*, side views, showing the thickness; 500 diam.; fig. 11, from the body: *a*, 1100 diam., as thick as broad; *b*, the same as *a*, 500 diam.; *c*, *d*, end views; *e*, with two mesoblasts; 500 diam.; fig. 12, flat corpuscles from the allantois: *a*, 1100 diam.; *b*, 500 diam. Period of laying unknown, opened Aug. 25, 1852.

Fig. 13 to 13c. Blood corpuscles, 500 diam.; fig. 13, flattened against each other; fig. 13a, a corpuscle squeezing between two others; fig. 13b, drawn out; fig. 13c, in a natural state, the left one seen edgewise, the middle one, from the side, the right one seen endwise. Laid June 12, opened Aug. 16, 1855.

Fig. 14. Bloodvessel from the pia mater, 500 diam.; *a*, *b*, mesoblasts in profile. Hatched in Oct. 1855.

Fig. 15. Cells of the olfactory nerve, close to the Schneiderian membrane, 500 diam.; *a*, *b*, nearly perfect nerve tubules. Hatched in Oct. 1855.

Fig. 16. From the hemisphere of the brain, section in profile, 500 diam.; *a*, outer stratum; *b*, *c*, inner strata of the cells of the pia mater; *d*, blood corpuscles; *e*, cells of the hemisphere; the same as fig. 15.

Fig. 16b. Cells at the surface of the hemisphere in profile; fig. 16c, cells of the hemisphere from the interior; *a*, single cells; *b*, *b'*, *c*, *c'*, altered by water; *b*, and *c*, the same cell seen from two different points of view, and magnified 1100 diam.; the others, 500 diam. Period of laying unknown, opened Sept. 6, 1852.

Fig. 17, 17a, 17b. Cells of the olfactory nerve, just before the olfactory lobe; fig. 17, cells at various depths; fig. 17a, at one focus, the surface of the cells; fig. 17b, a little deeper, so as to show the thickness of the walls; 500 diam.; the same as fig. 15.

Fig. 18. Cells of the olfactory lobe; *a*, caudate cell, 500 diam.; the same as fig. 16b; fig. 18a, cells of the pia mater of fig. 18; 500 diam.

Fig. 19. Cells of the Schneiderian membrane; *a*, in a natural state; 19, altered by water; *b*, single cells of 19: 500 diam.; the same as fig. 16b.

Fig. 20. Cells of the medulla oblongata; *a*, *a*, caudate cells: *b*, nearly filled by the mesoblast; 500 diam.; the same as fig. 16b.

Fig. 21. Cells from the spinal cord, just behind the medulla oblongata, 500 diam.; the same as fig. 16b.

Fig. 22. Chorda dorsalis, 500 diam. Laid July 18, opened July 27, 1852.

Fig. 23. Passage of muscles into cartilage, from the dorsal arch; *a*, *b*, muscle; *c*, cartilage cells; 500 diam. Period of laying unknown, opened Aug. 25, 1852.

Fig. 24. Muscular fibre macerated in water; *a*, transverse section; 500 diam.; the same as fig. 25.

Fig. 25. Muscular fibre from the foreleg; *a*, fibre; *b*, beaded fibrillæ; 800 diam.; the same as fig. 16b, etc.

Fig. 26. Tendinous fibrillæ; fig. 26a, in a contracted state; 500 diam.; the same as fig. 16b.

Fig. 27. Muscular fibre from the upper retractor muscles of the head, 800 diam.; fig. 27a, a beaded fibril, 1100 diam. Laid June 21, opened Oct. 19, 1855. No fig. 28.

Fig. 29. Cells of the gall cyst, in profile; *a*, outer surface; *b*, single cell; fig. 29a, surface view; 500 diam. Period of laying unknown. Just hatched.

Fig. 30. Cells of the ovary, 500 diam. Period of laying unknown. Just hatched.

Fig. 31. Cells of the liver; *a*, group; *b*, *b*, single cells: 500 diam. Period of laying unknown. Just hatched.

Fig. 32. Liver cells; *a*, single cells; 32, a group, 500 diam.; *b*, *c*, in water, 500 diam.; *b'*, *c'*, 1100 diam.; the same as fig. 16b.

Fig. 33. Contents of the gall cyst, 500 diam. Period of laying unknown. Just hatched.

Fig. 34. Contents of the gall cyst, 500 diam. Laid June 21, opened Oct. 17, 1855; *a* to *h*, blood corpuscles, in various stages of development; *i*, decomposing globules.

Fig. 35. First fæcal discharge, 36 hours after hatching, 500 diam.; fig. 35a, crystals of uric acid in the fæces, color greenish-yellow, 800 diam.; *a*, *b*, *c*, *d*, *e*, *f*, various combinations of crystals.

PLATE XX.

[Drawn from nature, by H. J. Clark.]

All the figures are from Chelydra serpentina.

Fig. 1, 1a, 1b. Uriniferous tube; fig. 1, seen endwise; fig. 1a, seen at the bend; fig. 1b, at the side; 500 diam. Period of laying unknown, opened Aug. 31, 1853

Fig. 2. Malpighian body from the kidney, 500 diam.; *a*, wall of uriniferous tube; *a'*, its cavity; *a''*, glomerulo; *b*, bloodvessel, artery? Laid June 12, opened Aug. 13, 1855.

Fig. 3. Windpipe, 500 diam.; *a*, fibrous connective tissue; *b*, *c*, ring of cartilage; *b*, central cells; *c*, cells at the edge. Period of laying unknown. Hatched in Oct.

Fig. 4. Portion of the lung, 250 diam.; *a*, outer wall; *a'*, *a'*, partitions; *b*, *b*, bloodvessels; *c'*, interior wall of the partitions; *c''*, incipient partition in profile; *e*, mucous membrane; *e'*, *e'*, mucous membrane of an incipient partition; *f*, lateral and downward projection of the larger partitions; fig. 4a, *a*, surface of the lung; *b*, bloodvessel; *d*, incomplete large partition; 250 diam. Laid June 18, opened Sept. 3, 1855.

Fig. 5. End of the lung, showing the pigment cells following the courses of the bloodvessels, 25 diam. Period of laying unknown, opened Sept. 2, 1852.

Fig. 6. Cartilage cells from the windpipe of fig. 5; 500 diam.

Fig. 7. A bronchiole of the lung surrounded by bloodvessels, 500 diam. Period of laying unknown, opened Aug. 28, 1852.

Fig. 8. Pigment cells from the surface of the lung, 500 diam.; the same as fig. 7.

Fig. 9. A bronchiole of fig. 5; *a*, cells of the mucous membrane; fig. 9a, the same, seen through the round cells on the surface of the lung; 500 diam.

Fig. 10. Portion of fig. 5; *a*, bronchioles; *b*, musculo-fibrous partitions; *c*, bloodvessels; 300 diam.

Fig. 11. Portion of fig. 5 still more magnified, 500 diam.; *a*, cells of the mucous membrane; *b*, a partition nearest to the surface of the lung; *b'*, a partition lying deeper.

Fig. 12. End of the lung when very young, 250 diam.; *a*, outer wall; *b*, mucous membrane. Laid June 21, opened July 31, 1855.

Fig. 13, and 13a. Cells of the mucous membrane of the urinary bladder, 500 diam.

Fig. 14. Cells of the interior muscular layers of the urinary bladder (fig. 13 and 13a); fig. 14a, outermost cells of the muscular layers, 800 diam.

Fig. 15. Inner ends of the cells (fig. 13, 13a) of the mucous membrane, 500 diam.

Fig. 16. Mesh of muscular fibres of the urinary bladder, 40 diam.

Fig. 17. Contents of the bladder, 500 diam.

Fig. 13 to 17 are drawn from the same specimen, just hatched, the period of laying of which was unknown.

Fig. 18. Cells of the epidermis on the right, and the pigment layer on the left; from beneath, 500 diam. Laid June 21, opened Oct. 17, 1855.

PLATE XXI.

[Drawn from nature, by H. J. Clark.]

Fig. 22, 23, 24, 25, 26, 30, from Chrysemys picta; fig. 27, and 28, from Nanemys guttata; the others from Chelydra serpentina.

Fig. 1. Profile of the inner cells of the mucous membrane of the œsophagus, 500 diam.

Fig. 2. Columnar cells of the mucous membrane of the œsophagus, 500 diam.

Fig. 3. Surface of the cells of the mucous membrane of the stomach, 800 diam.

Fig. 4. Single cells of fig. 3, 800 diam.; fig. 1 to 4, from the same animal; age not ascertained.

Fig. 5. Section of the mucous membrane of the œsophagus, 500 diam.; *a*, inner cells; *b*, columnar cells. Period of laying unknown, opened Aug. 30, 1852.

Fig. 6. Inner surface of the œsophagus, 500 diam.; the same as fig. 5.

Fig. 7. Single cells of fig. 5, *a*, 500 diam.

Fig. 8. Group of cells from fig. 6, in water, 500 diam.

Fig. 9. Profile outline of fig. 8, to show the relations of the two strata of cells, 500 diam.

Fig. 10. Epithelial cells at the base of the tongue, 500 diam. Period of laying unknown. Just hatched.

Fig. 11. Transverse section of a fold of the œsophagus, 500 diam.; *a*, inner cells; *b*, columnar cells; *c*, round cells; *d*, inner muscular coat; the same as fig. 10.

Fig. 12. Surface cells of œsophagus, with vibratile cilia, 800 diam.; the same as fig. 10.

Fig. 13. Very elongated cells from the muscular coat of the œsophagus, 800 diam.; fig. 13a, a single cell of fig. 13, 1100 diam.; the same as fig. 10.

Fig. 14. Inner surface of the stomach, 300 diam.; *a*, entrance to the glands; *b*, outlines of the glands; fig. 14a, open aperture of one of the glands, 500 diam.; fig. 14b, the same shut, 500 diam. Period of laying unknown, opened Sept. 9, 1852.

Fig. 14c. Profile of the epithelial cells of the stomach, 500 diam.; fig. 14d, and 14e, surface view of fig. 14c, 500 diam.; fig. 14f, and 14g, the same as fig. 14d, altered by water; 14g, *a*, a single cell with its lateral mesoblast, 500 diam. Period of laying unknown, opened Aug. 30, 1852.

Fig. 15. Surface of the stomach, looking into the glands, 300 diam.; fig. 15a, mouth of a gland, 500 diam.; *a*, epithelial cells of the stomach; *b*, mouth; fig. 16, lower half of a gland, outside view; fig. 16a, transverse section of fig. 16; fig. 16b, longitudinal section of fig. 16; 500 diam.; the same as fig. 1 to 5.

Fig. 17. A gland of the stomach in profile; *a*, surface of the stomach; *b* above, opening of the gland; *b* in the middle and below, its cavity; *c*, *d*, its walls; 500 diam. Just hatched.

Fig. 18. Section across the thick intestine, 500 diam.; *a*, *a'*, columns of cells of the mucous membrane; *b*, stratum of round cells; *c*, inner, and *d*, outer muscular coats; *e*, thin membrane inclosing the whole intestine; fig. 18a, the same as fig. 18, *a*, and *a'*, being seen in one focus; fig. 18b, two columns of cells separated so as to disclose the mesoblasts; fig. 18c, *a*, *b*, cells of fig. 18, segmenting; the same as fig. 17.

Fig. 19. Section across the long intestine, 500 diam.; *a*, *b*, *c*, *d*, *e*, as in fig. 18; the same as fig. 17.

Fig. 20. One of the claws, 25 diam.; *a*, horny sheath; *b*, interior cells of the claw; *b'*, cells at the base of the claw; fig. 20a, cells of the horny sheath, 500 diam., in profile; fig. 20b, the same as fig. 20a, view perpendicular to the surface; fig. 20c, cells at the end of the horny sheath, 500 diam.; fig. 20d, cells of the skin of the next joint, just beneath the sheath, 500 diam. Period of laying unknown, opened Aug. 25, 1852.

Fig. 21. The bone of the claw, 40 diam.; fig. 21a, cells at the surface of fig. 21, 500 diam.; the same as fig. 20.

Fig. 22. Cartilaginous matrix of a bone of the toe, 500 diam.; fig. 22a, separate cells of fig. 22. Period of laying unknown, opened in Sept., 1852.

Fig. 23. Cells at the surface of the foot, 500 diam.; the same as fig. 22.

Fig. 24. Piece of the bone of the toe, 500 diam.; the same as fig. 22.

Fig. 25. Interior cells of the foot, 500 diam.; the same as fig. 22.

Fig. 26. Cells of the shield, 500 diam.; the same as fig. 22.

Fig. 27. Cells of the ear, 300 diam. Laid July 18, opened July 28, 1852.

Fig. 28. Cells of the eye, 300 diam.; *a*, cells of the retina; *b*, skin of the head; *c*, passage-way to the brain; the same as fig. 27.

Fig. 29. Crystalline lens taken out of the eye with the surrounding membranes, 40 diam.; *a*, membrana pupillaris; *b*, pigment layer on the zonula Zinnii (*c*). Period of laying unknown, opened in Aug. 1852.

Fig. 30. Portion of the crystalline lens, 300 diam.; *a*, the converging ends of the fibres *b*; the same as fig. 22.

Fig. 31. The converging ends of the fibres of the crystalline lens, 300 diam.; the same as fig. 29.

Fig. 32. Part of a section through the centre, from front to back, of the crystalline lens; *a*, the ends of the fibres, 40 diam.; fig. 32a, *a*, *b*, *c*, *d*, four fibres of fig. 32, 500 diam.; fig. 32b, large globules intermixed with the fibres, 500 diam.; fig. 32c, portion of a fibre twisted so as to show a combined view of the edge and of the flat side, 500 diam.; fig. 32d, ends of fibres swollen by water, 500 diam. Period of laying unknown, opened Sept. 9, 1852.

Fig. 33. Section of the thickness of the retina at a point midway between the front and back of the eye, 500 diam.; *b*, *c*, cells of the inner or first layer; *d*, second layer; *e*, *f*, third layer; *g*, fourth layer; *h*, *i*, membrana Jacobi; *i'*, outer prolongations of *h* and *i*; fig. 33a, cells of the membrana Jacobi, with their yellow and orange mesoblasts, 1100 diam. Hatched Oct. 1855.

Fig. 34. Profile of the mucous membrane of the thick intestine, 500 diam.; fig. 34a, surface view of fig. 34, altered by water; *b*, a group; *c*, single cell; 500 diam.; the same as fig. 15. These two figures are between fig. 14 and fig. 15, and erroneously marked 20 and 20a.

PLATE XXII.

[Drawn from nature, by H. J. Clark.]

Fig. 1, from Thalassochelys Caouana; fig. 7, from Trachemys serrata; all the others from Chelydra serpentina.

Fig. 1. Obliquely transverse section of a rib, 500 diam.; *a*, innermost cartilage cells; a^1, a^2, a^3, successively nearer to the surface of the bone; *b*, innermost layer of the fibrous layer next to the cartilage cells; *b*, *c*, *d*, *e*, *f*, *g*, successively nearer to the surface of the bone; *h*, corium; g^1, granular, hardened fibrillæ of the outer layer of the bone: h^1, similar soft fibrillæ of the corium; fig. 1a, a single cartilage cell, 800 diam.; *a*, parietes of the blastematous cavity; *b*, cell wall shrunk; *c*, mesoblast; fig. 1b, the same as fig. 1a, 1100 diam. Just hatched.

Fig. 2. Transverse section of a rib; the letters are the same as in fig. 1.

Fig. 3. Strip from the inferior face of a vertebra, 500 diam., view from within; *a*, fibres running in the direction of the length of the vertebra; *b*, more interior layer: *c*, still deeper; *d*, innermost layer; fig. 3a, granular fibrillæ of fig. 3, *b*, 800 diam. Just hatched.

Fig. 4. Transverse section of the interior portion of the ventral half side of a vertebra, 500 diam.; *a*, *b*, granular lining of cells; *c*, ossification encroaching upon the cells; *d*, coarse granular ossification; *e*, mesoblast of the cells; the same as fig. 3; fig. 4a, *a*, *b*, crystals of nitrate of lime.

Fig. 5. Transverse section of the cartilage cells of the coracoid bone, 500 diam.; *a*, blastema; *b*, cells. Just ready to hatch.

Fig. 6. Longitudinal section of fig. 5; *a*, *b*, the same as in

fig. 5; fig. 6a, in alcohol, *c*, the cell wall has shrunk; fig. 6b, a single blastematous cavity (*a*); *b*, the cell wall shrunk; *c*, the mesoblast; the same as fig. 5.

Fig. 7. Part of a longitudinal section through the middle of the eye of an adult Trachemys serrata, 10 diam.; *a*, sclerotic portion of the conjunctiva; *a*¹, conjunctiva; *a*², fold where *a* and *a*¹ join; *b*, sclerotica; *c*, sclerotic squamula; *c*¹, cornea; *c*², base of iris; *d*, pigment layer; *e*, choroidea; *e*¹, iris; *e*², posterior lining of the iris, or ciliary process; *e*³, posterior border of the ciliary process; *f*, *f*¹, pigment layer lining the choroidea (*e*); *g*, membrana Jacobi; *g*¹, anterior border of *g*; *h*, retina; *i*³, anterior edge of *h*; *i*, fibrous layer; *k*, membrana hyaloidea; *k*¹, prolongation of *k* over the back of the crystalline lens (*l*); *k*³, fold where *k* recurves; *l*, crystalline lens; *m*, *m*′, triple wall of the capsule of the lens; *n*, the membrana pupillaris; *n*¹, border of *n*.

Fig. 8. Longitudinal section through the middle of the left eye of a Turtle just hatched, about 10 diam. The optic nerve (*h*¹) is introduced here out of place, to show its relation to the retina. The letters are the same as in fig. 7, to which are added: *b*¹, continuation of the sclerotica over the optic nerve; *d*¹, posterior termination of the pigment layer which covers the choroidea (*e*); *e*⁴, (this letter is erroneously marked *e*′ in the plate, near *h*′,) continuation of the choroidea (*e*) over the optic nerve, *h*¹; fig. 8a, portion of fig. 8, about 20 diam., to show more distinctly the different membranes and layers of the eye bulb. The letters are the same as in fig. 8.

Fig. 9. Transverse section of the head through the eyes, 10 diam., date not noticed; *a*, musculo-cutaneous layer; *b*, corpora quadrigemina; *c*, eye; *c*¹, aqueous humor; *c*², crystalline lens; *d*, vitreous humor; *d*′, retina; *e*, anterior half of the orbit of the eye, empty; *b*¹, hemispheres; *b*², the separate edges of *b*¹.

PLATE XXIII.

[Drawn from nature, by H. J. Clark.]

All the figures are from Chelydra serpentina. Fig. 1, 1a, 2, 2a, 2b, 2c, 2d, and 3, are all lettered alike: *a*, hemispheres; *b*, corpora quadrigemina; *c*, olfactory bulb; *c*′, Schneiderian membrane; *c*″, the same as *c*′ cut across; *c*‴, septum narium; *d*, pineal gland; *e*, cerebellum; *e*′, edge of the still open portion of the spinal tube; *f*, upper wall of the spinal tube; *g*, vascular pia mater; *g*′, choroid plexus over the medulla oblongata (*p*); *h*, the eyes; *i*, spinal tube; *k*, optic lobes; *k*¹, optic nerve; *l*, auditory nerve; *m*, opening on the inner face of the hemispheres; *n*, commissure of the hemispheres; *o*, floor of *b*, the so-called pons Varolii; *o*¹, fourth ventricle; *p*, medulla oblongata; *p*′, commissure of the optic lobe; *p*″, anterior end of the commissure of the optic lobe.

Fig. 1. View of the left side of the brain and part of the spinal tube, about 3 diam. Laid June 23, opened Aug. 22, 1855; fig. 1a, the same as fig. 1, a longitudinal median section; about 4 diam.

Fig. 2. Left side of the brain and part of the spinal tube, 3 diam. Laid June 12, opened Aug. 16, 1855. Fig. 2a, view from above of fig. 2; 3 diam. From *c* to *c*′, the olfactory nerve and the Schneiderian membrane are raised up higher than is natural. Fig. 2b, longitudinal median section of fig. 2 and 2a; nearly 6 diam. (In this figure *p* should be *k*, and *k*, just before it, should be *k*′.) Fig. 2c, transverse section of the Schneiderian membrane; 10 diam. Fig. 2d, longitudinal and horizontal section of the hemisphere, exposing the interior and the corpora striata (*r*); *a*, walls of the hemispheres; *c*, olfactory lobe; *c*″, olfactory nerve. Fig. 2e, the choroid plexus taken out from the hemisphere, 20 diam. Fig. 2f, small tuft of fig. 2e. Fig. 2g, profile of fig. 2f; *s*, a single vessel from which several are budding. Fig. 2h, end of one of these vessels; *a*, inner wall, formed of long columnar cells; *b*, outer wall, formed of short and broad cells; the centre is full of blood corpuscles; 500 diam.

Fig. 3. Longitudinal section of the brain and the skull, 5 diam.; 1, designates the crest of the occipital bone; 2, the base of the skull; 3, the ethmoid; 4, the end of the skull; 5, the end of the vomer; 6, the sphenoid; 7, the vertebræ of the neck; 8, the cartilaginous upper maxillary; 9, the entrance to the nostrils. Laid June 12, opened Aug. 28, 1855.

Fig. 4; compare wood-cut 3, p. 576. Longitudinal section of the head of a Turtle just hatched; 5 diam. An alcoholic specimen was used on account of the hardening of the brain; *a*, entrance to the nasal cavity; *b*, nasal cavity around which the Schneiderian expands; *c*, olfactory nerve; *d*, olfactory lobe; *e*, hemisphere with an opening on the inner face next to the commissure for the passage of the blood-vessel, (*e*′,) which expands in the interior into a vascular plexus in the form of a tuft; *f*, pineal gland, its superior or outer commissure (*f*′) cut through; *g*, corpus quadrigeminum, cut at the commissure so as to allow an interior view. The outlines of the surface of the right lobe may be seen in the distance under the vascular membrane (*g*′); *g*″, bloodvessel of the enveloping membrane, (pia mater,) which plunges between the corpora quadrigemina and the cerebellum (*k*); the same passes backwards into the great plexus (*k'*) in the cerebellum; *h*, optic lobe, its commissure cut through, both at the front and hind side; *h'*, optic nerve; *i*, anterior wall of the fourth ventricle cut through; *i'*, point where the medulla oblongata suddenly narrows and passes into the spinal tube (*l*); *k*, cerebellum terminating suddenly behind, against the choroid plexus (*k'*); *k''*, vascular membrane (pia mater) continuous from *k'* over the brain; *l*, spinal tube; the upper half of the tube suddenly thins out (*l'*) as it reaches the medulla oblongata; *m*, the partition between the eyes; *n*, the upper wall of the cranium; *n'*, the ossified portion; *n''*, ethmoid bone; *o*, muscular layer, which passes within and upon the inner surface of the upper wall of the cranium; *o'*, dorsal arch of the first vertebra cut through; *o''*, dorsal arch of the second vertebra cut through; *p*, os dentatum, cut through the axis; *p'*, its ligamentous attachment to the base of the skull (*r*); *p''*, *p'''*, the atlas; *p'''*, the upper half of the ring; *p''*, the lower half; *q*, second vertebra; *r*, basal occipital bone; *r'*, sphenoid bone; *r''*, vomer; *s*, fibrous layer of the roof of the mouth; *s'*, interior portion of *s*, where it hangs down loosely, and is more open, network like; *t*, anterior commissure of the upper jaw, quite hard from the considerable amount of ossification; *t''*, termination of the horny layer prolonged from the beak (*t'*); *u*, fibro-muscular tongue; *u'*, commissure of the lower jaw; this part is not yet ossified, but the darker part below is quite gritty with lime; *u''*, opening of the larynx (*v*); the darker transverse lines are the tracheal rings; *w*, tongue bone, not yet ossified.

Fig. 4a; compare wood-cut 4, p. 576. A brain like fig. 4, the olfactory and cerebral lobes cut open, and the right pineal gland and the right half of the corpora quadrigemina cut through more to the right than in fig. 4; 5 diam.; *c*, tube of the olfactory nerve exposed; *d*, olfactory lobe with very thick walls and a small cavity; *e*, cavity of the cerebral lobe nearly filled by the choroid plexus; *e'*, main vessel of the choroid plexus where it enters the cavity of *e*; *f*, pineal gland; *g*, corpus quadrigeminum of the right side cut through, considerably to one side of its commissure, to show the very thick upper wall; *k'*, choroid plexus of the fourth ventricle partly cut away, to show the lamellæ of which it is composed; *l'*, the upper edge of the open medulla oblongata. For the other parts compare fig. 4.

Fig. 5; compare wood-cut 5, p. 576. Transverse section through the anterior end of the medulla spinalis, the atlas, and a portion of the os dentatum, and also through the posterior end of the occipital crest; about 15 diam. Corresponds to the line F, in w-c. 3, p. 576; compare also fig. 4: *a*, *a'*, medulla spinalis; *b*, narrow furrow along the upper surface of *a*; *c*, medullary canal, with a ring of gray substance around it; *d*, pia mater; *d'*, bloodvessel; *e*, arachnoid; *f*, dura mater; *g*, vessels from the dura mater filling the vertebral canal; *h*, cervical muscles; *i*, processus dentatus, from the second vertebra; *i'*, the canal in the atlas for the passage of *i*; *j*, atlas, the dark part still soft and gelatinoid, the dead white (*k*, *k*) more cartilaginous; *l*, a small portion of the atlas ossified; *m*, *m'*, occipital crest; *m*, the yet cartilaginous part; *m'*, part where a bony deposit has taken place; *n*, muscle running close to, and parallel with, the crest; *o*, dorsal muscles of the neck; *p*, musculus intertransversalis; *p'*, musculus retractor capitis.

Fig. 6; compare wood-cut 6, p. 576. Transverse section through the posterior edge of the cerebellum, the choroid plexus over the fourth ventricle, the medulla oblongata and the lower jaw; 5 diam. Corresponds to the line E, in w-c. 3, p. 576; compare also fig. 4: *a*, cerebellum, just in front of its posterior edge; *a'*, the same in the distance, where it descends to join (at *a''*) the corpora quadrigemina; *b*, *b'*, choroid plexus cut obliquely to the trend of its oblong mass, showing the lamellar structure; *c*, right, and *c'*, left half of the medulla oblongata; *c''*, furrow (in *c*, *c'*) which leads to the canal of the spinal tube; *c'''*, cavity of the fourth ventricle; *d*, pia mater; *d'*, arachnoid; *d''*, dura mater; *e*, vestibule exposed, and here and there cut across; *e'*, tympanic cavity; *f*, still cartilaginous cranium; *g*, muscles attached to *f*; *h*, fibro-spongiform mesh between *g* and *i*; *i*, membrane of the palate; *i'*, fibro-muscular membrane of the floor of the mouth; *j*, windpipe; *k*, hyoid bone; *l*, left branch of the lower jaw; *m*, bloodvessels cut across; *n*, muscles; *o*, lateral muscles of the jaw; *p*, muscles from the neck; *q*, deep fold of the skin cut across; *r*, dense fibrous corium.

Fig. 7; compare wood-cut 7, p. 577. Transverse section through the corpora quadrigemina, the third ventricle, the cochlea of the ear, the tympanic cavity, and the lower jaw; 5 diam. Corresponds to the line D, in w-c. 3, p. 576; compare also fig. 4. This view is from the front, looking backwards. *a*, the right, and *a'*, the left half of the corpora quadrigemina; *b*, the cavity of *a*, *a'*, communicating through a narrow space (*b'*) with the fourth ventricle, (*b''*.) which has its commissure just before this point; *c*, the right, and *c'*, the left fourth ventricle; *d*, inferior commissure of *c*, *c'*, a portion of the fourth ventricle being cut away to expose the origin of the auditory nerve. (*e'*.) which expands (*e''*) in the cavity of the vestibule; *f*, prolongation of the pia mater over the nerve *e′*, and *f′*, over its expansion; *g*, a branch of the vestibule cut across; *h*, *h′*, the cartilaginous cranium; *i*, tympanic cavity; *k*, pia mater; *k′*, bloodvessels from *k* plunging into the mass of the brain; *l*, dura mater; *m*, vessels of the median sinus; *n*, fibrous membrane of the palate; *n′*, lateral sinus of the fibro-muscular membrane of the mouth; *o*, windpipe; *p*, os hyoides; *q*, muscular bundles; *r*, adductor muscles of the neck; *r′*, muscles of the lower jaw; *s*, bloodvessels cut across; *t*, dense white fibrous corium; *u*, epidermis very much wrinkled.

Fig. 8; compare wood-cut 8, p. 577. Transverse section through the hemispheres, the optic lobe, and the lower jaw, just behind the opening of the windpipe; 5 diam. Corresponds to the line C, in w-c. 3, p. 576; compare also fig. 4. View from before, looking backwards; *a*, left hemisphere, the rudimentary corpus striatum lies at the point where the letter is placed; *a″*, crura cerebri; *b*, *b′*, interior face of the hemispheres; *b* is partly cut away to expose the bloodvessel (*c′*) going to the choroid plexus, (*d*,) which enters by the foramen at this point; *c*, bloodvessel which enters at *c′*; *d*, choroid plexus; *e*, third ventricle in the distance; *f*, *f′*, optic lobes; *g*, inferior commissure of *f* and *f′*; *h*, parietal bone of the skull; *h′*, frontal bone; *i*, sphenoid bone; *j*, cavity of the mouth; *k*, fibro-muscular layer of the floor of the mouth; *k′*, roof of the mouth; *l*, windpipe; *m*, middle part of the hyoid bone; *n*, bloodvessels; *o*, muscular bundles; *p*, *p′*, *p″*, three parts of the lower jaw, *p* still cartilaginous, the two others quite gritty with lime; *q*, fibrous corium.

Fig. 9; compare wood-cut 9, p. 577. The same section as fig. 8, looking forward on the opposite side of the cut toward the olfactory lobes; 5 diam.; *b″*, open communication between the hemispheres; *d″*, narrow passage in the olfactory lobe in the distance; *e′*, anterior commissure of the optic lobes. The other letters as in fig. 8.

Fig. 10; compare wood-cut 10, p. 577. Transverse section through the anterior end of the olfactory lobe and a portion of the surrounding tissues, seen from behind; 15 diam. Corresponds to the line B, in w-c. 3, p. 576; compare also fig. 4: *a*, the right olfactory lobe, marked by concentric layers of alternately white and gray substance, the white being much thicker than the gray; *b*, ventricle in the centre of the lobe; *c*, the vascular pia mater; *d*, arachnoid membrane, or network of vessels connecting the pia mater (*c*) to the dura mater (*d′*); *e*, interorbital septum; *f*, frontal bone; *g*, fibrous corium; *h*, layer of pigment under *i*; *i*, the epidermis.

Fig. 11; compare wood-cut 11, p. 557. Transverse section through the nasal cavity, seen from behind; 5 diam. Corresponds to the line A, in w-c. 3, p. 576; compare also fig. 4: *a*, right Schneiderian membrane; that part which is below the palate bone (*f*) is not seen in the longitudinal section, (fig. 4,) which is made through the middle line of the head; *b*, septum narium; *b′*, the irregular dotted line next to *a* indicates a dense layer of black pigment; *c*, frontal bone; *d*, ethmoid; *d′*, upper edge of the intermaxillary bone, os incisivum; *e*, corium; *f*, vomer; *g*, palate; *h*, inner edge of the horny layer of the mandible, where it meets the mucous membrane (*i*) of the palate (*g*).

PLATE XXIV.

[Fig. 7, 7a, 9, 9a, 15, from nature, by A. Sonrel; the others by H. J. Clark.]

Fig. 8 and 14 are from Nanemys guttata; the others from Chelydra serpentina.

Fig. 1, 1a, 2, 2a, 3, 3a, 4, 5, 7, 7a, 8, 9, 9a, 11, 12, 13, 13a, 14, 15, are all lettered in the same manner: *a*, amnios; a^2, caudal hood; *e*, edge of the channel of the spinal marrow; e^2, edge of the open part of the brain; e^3, brain closed over; e^4, constriction between the corpora quadrigemina and the optic lobes; *f*, vertebræ; *f′*, vertebral layer; f^2, lower edge of *f*; f^3, lower edge of *f′*; f^4, upper edge of *f*; h^1, aortic bulb; h^2, auricle; h^3, ventricle; *i*, vena afferens; i^2, abdominal veins; i^3, cephalic veins; *j*, cephalic artery; j^2, dorsal artery; *k*, the whole eye, or the outer layer of the retina; *k′*, the inner infolded layer; k^2, passage to the brain; k^3, crystalline lens; k^4, point where the inner wall (k^1) folds upon the outer (*k*); *l*, ear; *m*, branchial fissures; *n*, intestino-subsidiary layer; n^3, stomach; n^4, œsophagus; n^5, anus; n^6, allantois; *o*, edge of the abdominal aperture; *p*, musculo-cutaneous layer; *r*, liver; *t*, windpipe; *t′*, lungs; *v*, nostrils; *w*, fore legs; w^1, hind legs; *x*, mouth; 1, outer wall of the lungs; 1′, outer wall of the œsophagus behind the lungs; 1″, outer wall of the œsophagus before the lungs; 1‴, outer wall of the windpipe; 2, mucous membrane of the lungs; 2′, mucous membrane of the œsophagus behind the lungs; 2″, mucous membrane of the œsophagus before the lungs; 2‴, mucous membrane of the windpipe; 3, opening of the windpipe; 5, open communication between the windpipe and the œsophagus; 6, part of the trachea of the right lung; 7, a bronchiole trending transversely to the broad face of the lung.

Fig. 1. The lungs, and part of the œsophagus, from below, 40 diam., date not ascertained; fig. 1a, interior walls of fig. 1; 250 diam.

Fig. 2. Lungs and stomach, from below, about 5 diam.; laid

June 21, opened July 31, 1855; fig. 2a, a lung from fig. 2, 40 diam.

Fig. 3. Lungs and windpipe, from below, slightly magnified; fig. 3a, the same as fig. 3, one lung is turned so as to show the broad side, 40 diam.; laid June 23, opened July 30, 1855.

Fig. 4. Left lung and the windpipe, in profile, 25 diam.; laid June 12, opened July 29, 1855.

Fig. 5. Left lung, the side next to the œsophagus, 25 diam.; laid June 23, opened Aug. 7, 1855.

Fig. 6. Part of a trachea close to the lung, 40 diam.; period of laying unknown, opened Sept. 2, 1852.

Fig. 7. Left side of the head and shoulders, 25 diam.; period of laying unknown, opened July 30, 1852; fig. 7a, head of fig. 7, seen from the end.

Fig. 8. The right eye, 40 diam.; laid June 22, opened July 22, 1852.

Fig. 9 and 9a, 25 diam.; period of laying unknown, opened Aug. 7, 1852. Fig. 9a, head, heart, and shoulders from below; fig. 9, region of the heart of fig. 9a, the right side. (In this figure, i^3 should be j^3, and j^3 should be i^3.)

Fig. 10, 10a, 10b. The heart, 5 diam.; fig. 10, the ventral face; fig. 10a, the dorsal face; fig. 10b, the ventral face, the ventricle (h^4) cut open. In all three figures, h^1, h^1, indicates the pulmonary arteries; h^2, h^3, the auricles; h^4, the ventricle; *pa*, the left aorta; the double vessel without letters is the right aorta; *vo*, valvular opening between the auricles and ventricle; *vl*, valves of *vo*; laid June 18, opened Sept. 3, 1855.

Fig. 11. The head, from below to show the mouth, 3 diam.; laid June 21, opened Aug. 8, 1855.

Fig. 12. The head of fig. 9a cut off and seen from behind, about 5 diam.

Fig. 13. Posterior end of Pl. 12, fig. 1, from above, 250 diam.; fig. 13a, surface of fig. 13.

Fig. 14. Posterior end of the left side of the body, 25 diam., seen on dark ground; laid July 14, opened Aug. 25, 1852.

Fig. 15. Posterior end of the left side of the body, 8 diam.; period of laying unknown, opened July 31, 1852.

PLATE XXV.

[Fig. 2, 8, 9, 10, from nature, by A. Sonrel; all the others by H. J. Clark.]

Fig. 9. Cistudo virginea: fig. 10, 11, Chrysemys picta; fig. 12, Ozotheca odorata; the others, Chelydra serpentina.

Fig. 1, 1a, 3, 3a, 9, 10, are lettered in the same manner: *bk*, beak; *h*, heart; *h'* aorta; n^1, intestine; n^2, stomach; n^4, œsophagus; n^5, anus; n^6, urinary bladder, or in fig. 3, allantois; n^7, remains of the neck of the yolk sac, or in fig. 3 and 3a, the whole yolk sac; *oh*, hyoid bone; *q*, Wolffian bodies; *r*, liver; *t*, windpipe; *t'*, lungs; *v*, nostrils; *x*, lower jaw in fig. 1a, opening of the mouth in fig. 9 and 10.

Fig. 1. Intestines, heart, and liver, seen from below, 2½ diam.; period of laying unknown, opened Aug. 30, 1851. Fig. 1a, intestine stretched out, nat. size; fig. 1b, junction of the œsophagus and intestine, cut open, seen from within, 5 diam.; fig. 1c, piece of the long intestine laid open, 5 diam.; fig. 1d, piece of the thick intestine laid open, 5 diam.

Fig. 2. See below, after fig. 3 and 3a.

Fig. 3. Cut open from below, nat. size, just hatched; fig. 3a, cut open from above; the yolk sac (n^7) has lost part of its contents, and shrunk; the dotted line indicates its outlines when uninjured.

Fig. 2, 4, 5, 6, 6a, 7, 7a, are lettered in the same manner: *a*, the Wolffian bodies; *a'* in fig. 6b is the same as *d*; *b*, kidneys; *b'*, posterior, and *b''* anterior end of *b*; *c*, duct of Wolffian body; *c''*, posterior opening of *c*; *d*, abdominal veins, see also *a'* above, in fig. 6b; *e*, ureters of the kidneys; *f*, vas deferens of the testicle (*n*); *g*, anal pouches; *g'*, aperture of *g*; *h*, dorsal or abdominal artery, or in fig. 2, the heart; *h'*, arteries going to the hind legs; in fig. 2, it is the aorta; *i*, vena afferens; in fig. 6 and 7, it is put by mistake for the vessels which go to the Malpighian corpuscles; j^1, j^1, forks of the omphalo-meseraic artery; *k*, intestine; *l*, cloaca; *m*, anus; *m'*, opening of the intestine into the cloaca; *n*, genital organ; *n'*, anterior prolongation of *n*; *o*, allantois; *r*, liver; *u*, gall cyst.

Fig. 2. Heart, liver, Wolffian bodies, and kidneys, seen from the right side, 6 diam.; laid June 18, opened Sept. 4, 1855.

Fig. 4. Left Wolffian body in profile, 6 diam.; laid June 12, opened Aug. 13, 1855.

Fig. 5. Piece of the left Wolffian body and kidney, 12 diam.; period of laying unknown, opened Aug. 31, 1852.

Fig. 6. Wolffian bodies and kidneys, from above, 6 diam.; fig. 6a, the same as fig. 6, from below; fig. 6b, transverse section of fig. 6, and 6a; laid June 12, opened Aug. 29, 1855.

Fig. 7. Left Wolffian body and kidney, from below, 5 diam.; fig. 7a, upper side of fig. 7, the upper end is the anterior. Just hatched.

Fig. 8. An embryo deprived of its envelopes, 2 diam.; the same as Pl. 15, fig. 4, 5, 5a, 6.

Fig. 9. Head of Pl. 18, fig. 10d, 3½ diam.

Fig. 10. Head of Pl. 16, fig. 1; 4 diam.

Fig. 11. Left anterior foot, 25 diam.; period of laying unknown.

Fig. 12. Left fore foot, from above, 10 diam.; period of laying unknown, opened Aug. 25, 1852.

Fig. 13. Brain of an adult Chelydra serpentina, from above; fig. 13a, the same as fig. 13, seen in profile from the left side, slightly magnified; *c*, cerebellum; *h*, hemispheres; *i*, pituitary body; *n*, nostrils; *sm*, Schneiderian membrane; *, cut edge of the cartilaginous box surrounding the nasal cavity; *on*, olfactory nerves; *ob*, olfactory bulb; *pg*, pineal gland; *cq*, corpora quadrigemina; *pc*, plexus choroideus; *no*, optic nerve. A comparison of these two figures with those of Plate 23 will readily show the remarkable changes which the brain undergoes, even after its parts are well defined. A further comparison of these figures with those of Plates 12, 18a, and 24, will exhibit the whole range of the transformations of that organ, from its first appearance to its complete growth.

PLATE XXVI. and XXVII.

[Painted from nature, by J. Burkhardt.]

These two Plates exhibit the range of variations of the colors in one and the same species, and the successive changes in their distribution, as well as in the tints. It is the Emys rubriventris *Auct.*, rugosa *Shaw.*

Pl. 26, fig. 1 to 4, represents a young Ptychemys rugosa in four different views, just hatched: fig. 5 to 7, three different specimens, three or four years old, in profile, and from above, two thirds the natural size; fig. 8, specimen five or six years old, reduced nearly one half, from below; fig. 9, specimen about 7 years old, reduced one third; fig. 10 and 11, half grown specimens, about ten or twelve years old, reduced one half.

Pl. 27, fig. 1 to 3. Full-grown specimens, reduced one half; fig. 4, the eye, natural size; fig. 5, front view of the head, reduced one half.

APPENDIX AND ERRATA.

While the first volume was passing through the press, Dr. John E. Gray published a highly valuable and very important contribution to the Natural History of the Testudinata, under the title of "Catalogue of Shield Reptiles in the Collection of the British Museum," a copy of which I have lately received through the kindness of the author. This work is accompanied with a large number of remarkably well executed plates. A few additional remarks upon the North American species are rendered necessary by its appearance.

Dr. Gray supposes that the hind lobe of the sternum may be movable in the females of all the species of genuine Testudo; and on that account he objects to the genus Chersus of Wagler. In the species of our Southern States, this is certainly not the case. I have seen several specimens lay eggs in my garden, the sternum of which was as immovable as that of the males.

Dr. Gray still unites the Chelydroidæ and Cinosternoidæ with the Emydoidæ. I hold this to be an oversight of their true relations.

Under the generic name of Geoclemys, Gray unites three of our North American species, — which I have referred to the genera Glyptemys, Calemys, — and Nanemys, with three Asiatic species, which certainly are not very closely allied to them, if I may judge by his figure of Geoclemys Reevesii. These Asiatic species seem rather to belong to the genus Graptemys.

Contrary to the law of priority, Dr. Gray does not retain the name of Emys for the European Testudo lutaria, but applies it nearly in the same way as Duméril and Bibron. Among his North American Emys, there are several which are only nominal species. I trust that the evidence I have adduced in the case of Ptychemys rugosa is sufficient to show, that, in some types, the color does not afford specific characters. This is the case, to the same extent, with Ptychemys concinna, which is mentioned under four different names by Dr. Gray, — as Emys ornata, E. floridana, E. annulifera, and Pseudemys concinna. Ptychemys mobiliensis appears twice, — as Emys mobiliensis and as E. ventricosa. Ptychemys rugosa also appears twice, — as Emys rivulata and Pseudemys serrata. These facts are sufficient to show that Gray's genus Pseudemys is not well founded, as the two species which he himself had an opportunity of examining are only varieties of other species which he refers to the old genus Emys. I am unable to refer his Emys venusta with certainty, as his figure, though very well drawn, does not exhibit the generic characters. I believe it, however, to be one of the many varieties of Ptychemys concinna. The same remark applies to Emys callirostris. As stated p. 435, Emys Holbrookii *Gray* is Emys elegans *Neu-Wied*, a western species, which Gray was unable to refer. It belongs to the genus Trachemys.

Among the species requiring further examination, Gray mentions Emys reticularia or reticulata. As I have stated p. 441, this is a very distinct species, the type of a distinct genus, which I have named Deirochelys. Emys mobiliensis is also a distinct species, belonging to the genus Ptychemys; and so in Emys labyrinthica, Emys Troostii comes nearest to Emys scabra, the Emys serrata of the North American Herpetology, but it is quite distinct, and belongs, with the latter, to the genus Trachemys.

I do not know Gray's Emys olivacea, and doubt its being a North American species. I have, at least, never seen a Turtle like that in the United States.

Gray is certainly mistaken in referring Emys oregonensis as synonyme to Chrysemys Bellii. Through the kindness of my friend, James M. Barnard, I have lately received a dozen living specimens of Chrysemys oregonensis, — or rather Nuttalii, as I would now call it, — and feel satisfied that it is distinct from Ch. Bellii, of which I have also seen a large number of living specimens. They differ not only in the pattern of their color, but they occupy also different tracts in the western Fauna. Chr. Nuttalii is a more northern species. This species is inscribed in our herpetological works as Emys oregonensis; but as there is no evidence of its occurrence in Oregon besides the alleged indication of Mr. Nuttal, who probably collected it on this side of the Rocky Mountains, where it is common in Minesota and westward to the junction of the Yellowstone and Missouri, I propose henceforth to call it Chrysemys Nuttalii, in commemoration of its distinguished discoverer.

Should the fossil Turtle described by Pomel as Ptychemys prove to constitute a natural genus, I propose, for our living species, to change the name of Ptychemys to Nectemys.

I am glad to find that Dr. Gray has himself given up the genus Onychotria, against the adoption of which I have raised objections, (p. 445.) It remains now to be ascertained whether the Mexican three-toed Cistudo differs from that of our Southern States.

Gray describes two Cinosternums from North America as new species, founded upon young specimens. I confess my inability to distinguish them from Cin. pennsylvanicum; Cin. punctatum seems to me to be a young male, and Cin. Hippocrepis a young female, with a rather narrow hind lobe of the sternum, as is occasionally the case in Cin. pennsylvanicum. I have seen such large numbers of Cinosternum pennsylvanicum, that I feel little doubt upon this point. It is gratifying to me to see that Gray has arrived at the same conclusion as I have expressed (p. 428) respecting his Cin. oblongum. As to Cinosternum scorpioides, cruentatum, Doubledayi, and leucostomum, I refer simply to what I have already stated p. 426, note 1, and p. 429.

The genus Aromochelys *Gray* embraces the two genera which I have distinguished as Ozotheca and Goniochelys. His Aromochelys odorata is the same as my Ozotheca odorata, and his Aromochelys carinata is identical with my Goniochelys triquetra. Gray's genus Macroclemys is also identical with my Gypochelys.

The British Museum must be very indifferently provided with specimens of North American Trionychidæ, since Dr. Gray has failed to perceive the generic and specific differences which exist among them, and which his extensive knowledge of this family would at once have pointed out to him. As it is, he confounds the southern Trionyx ferox with the northern spinifer, and considers Trionyx muticus as a very doubtful species. I have shown (p. 398-405) that they belong to three different genera, and that three other species of this family, found in the rivers of North America, have remained unnoticed to this day.

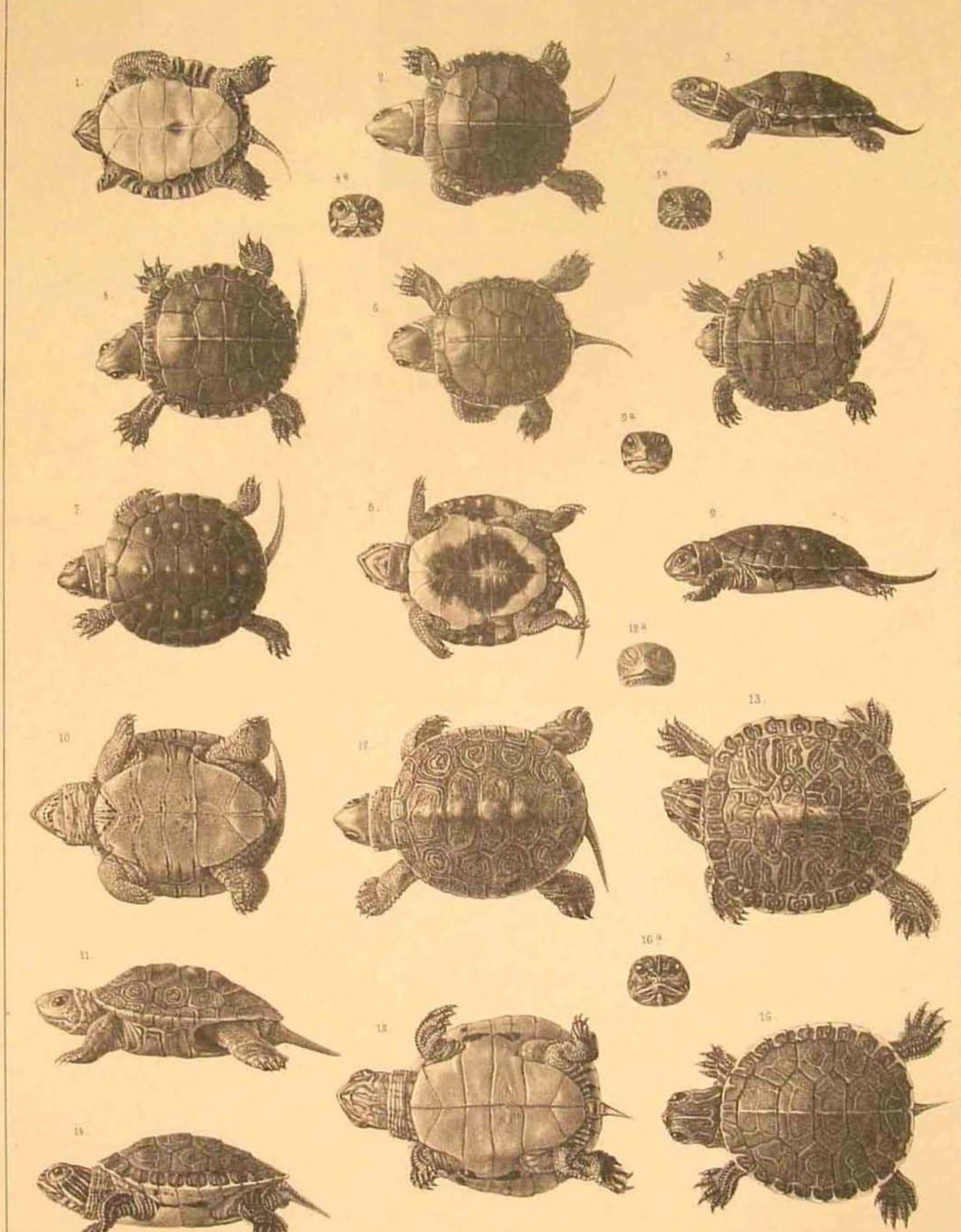
ERRATA IN THE TEXT.

Page 11, 2d line, *instead of* I shall consider, *read* is to be considered.
— 18, note, 2d col., line 10, *instead of* Naturwissenhaft, *read* Naturwissenschaft.
— 23, " " " " 7, " " McKoy, *read* McCoy.
— 29, 30th line, *instead of* the studies of which, *read* whose studies.
— 34, 18th " *for* has, *read* have.
— 35, 30th " " is, *read* are.
— 41, 15th " " insertivorous, *read* insectivorous.
— 43, 12th " " amimals, *read* animals.
— 43, 17th " " Betrachians *read* Batrachians.
— 52, note 2d col., 8th line, *instead of* to deny, *read* in denying.

Page 53, line 1, *for* Runth, *read* Kunth.
— 53, " 2, " proves, *read* prove.
— 58, " 15, " constitutes, *read* constitute.
— 87, " 22, " substract, *read* remove.
— 87, note, 2d col., 12th line, *for* Bishoff, *read* Bischoff.
— 96, " 1st " 19th " " Rœmer, *read* Rœmer.
— 108, line 30, *for* Cinoids, *read* Crinoids.
— 110, " 16, " Shrimb, *read* Shrimp.
— 112, " 14, " anathic, *read* ananthic.
— 112, " 16, " Cryptoganes, *read* Cryptogams.
— 113, " 35, " peduncated, *read* pedunculated.
— 117, " 25, " Crustacea, *read* Cetacea.
— 119, " 24, " Bruchyoura, *read* Brachyoura.
— 122, last line, " are, *read* is.
— 139, " " *instead of* Enecima and Anecima, *read* Enaima and Anaima.
— 150, 9th " *after* artificial, *insert* those.
— 153, 13th " *for* types, *read* branches.
— 156, 27th " " Asidians, *read* Ascidians.
— 167, 8th " " represent, *read* represents.
— 174, 9th " *after* have, *insert* occasion.
— 175, note, 1st col., 2d line, *for* Chelonara, *read* Chelonura.
— 177, 19th line, *for* has, *read* have.
— 178, 24th " *instead of* studies ought indeed, *read* studies, indeed, ought to.
— 187, 5th " *after* Chimeræ, *add* and the Fishes.
— 199, 38th " *for* those, *read* that.
— 559, 38th " *after* aperture *insert* . *and read*: At its posterior end, it projects.
— 560, 16th " *instead of* p. 557, *read* 552.
— 566, 3d " " " the right one, *read* the left one.
— 566, 4th " " " fig. 10, *pa* and 10b, and *pa*, *read* 10, *h'*, *h'*, and 10b, *h'*, *h'*.
From p. 451 to p. 458, here and there *instead of* Graffian *read* Graafian.

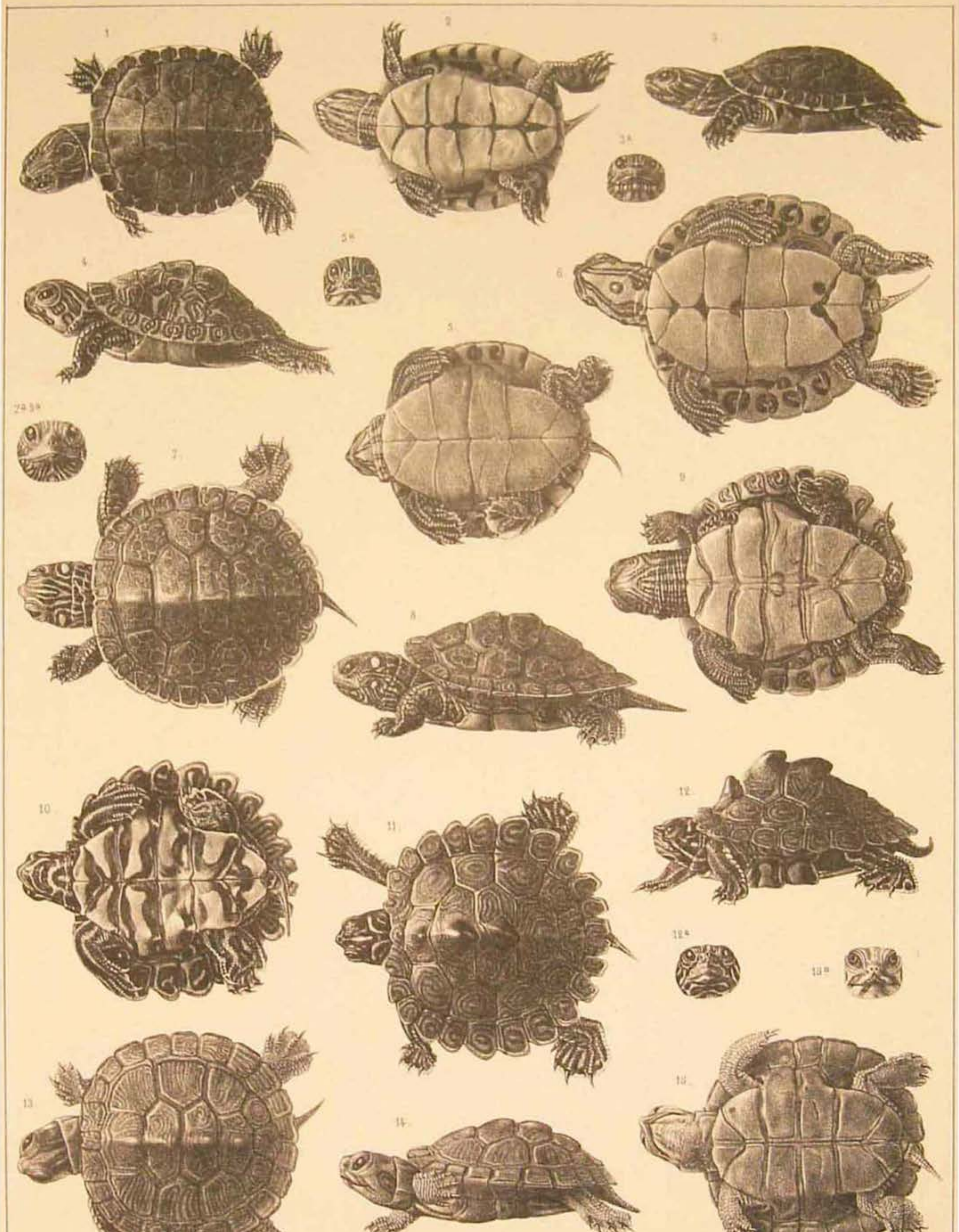
IN THE PLATES.

Plate 9c, fig. 5. The dots from the letter *c* on the right should go to the next inner line, which runs close to f^{3}.
— 11, " 3; *a*, must be *d*, as in fig. 2.
— 12, " 19; *c'*, must be *e'*.
— 12, " 10a; a^{4}, must be *a'*; correct the same, p. 541, line 16.
— 18a; fig. 2 in profile, should be fig. 8.
— 18a, fig. 13, h^{2}, and h^{1}. From h^{2}, a dotted line should go to the dark hole in the nearest part of the heart, and from *h'* to the part of the aorta which is just below the longest branchial fissure, (*m*,) that runs from the ear (*b*) downward. The letter *i*, nearest to the letter h^{2}, should be *i'*.
— 18^{4}, fig 14. The first letter to the left of *k* should be c^{3}, instead of *c'*.
— 21, fig. 20, 20a, near fig. 14, should be fig. 34, and 34a.
— 22, " 8; the letter *e'*, near *h'*, should be c^{4}.
— 23, " 2b; *p'* should be *k*, and the *k* just before it changed to *k'*.
— 24, " 9a; i^{3} should be j^{3}, and j^{3} should be i^{3}.



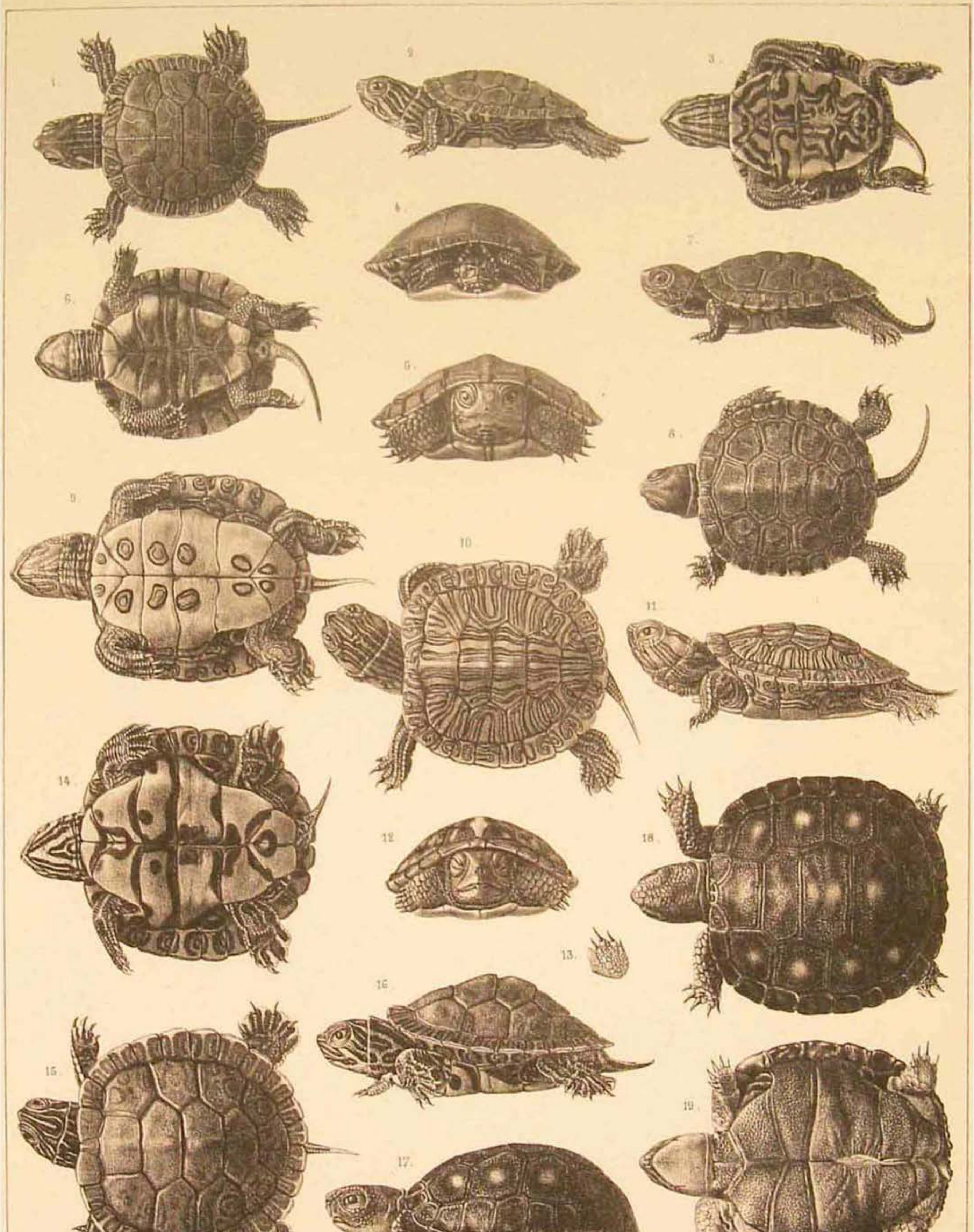
A. Sonrel on stone from nat. L. H. Bradford & Co. print.

1-5. CHRYSEMYS PICTA Gr. — 6. CHR. MARGINATA Ag. — 7-9. NANEMYS GUTTATA Ag. — 10-12. MALACOCLEMMYS PALUSTRIS Ag.
13. PTYCHEMYS CONCINNA Ag. — 14-16. DEIROCHELYS RETICULATA Ag.



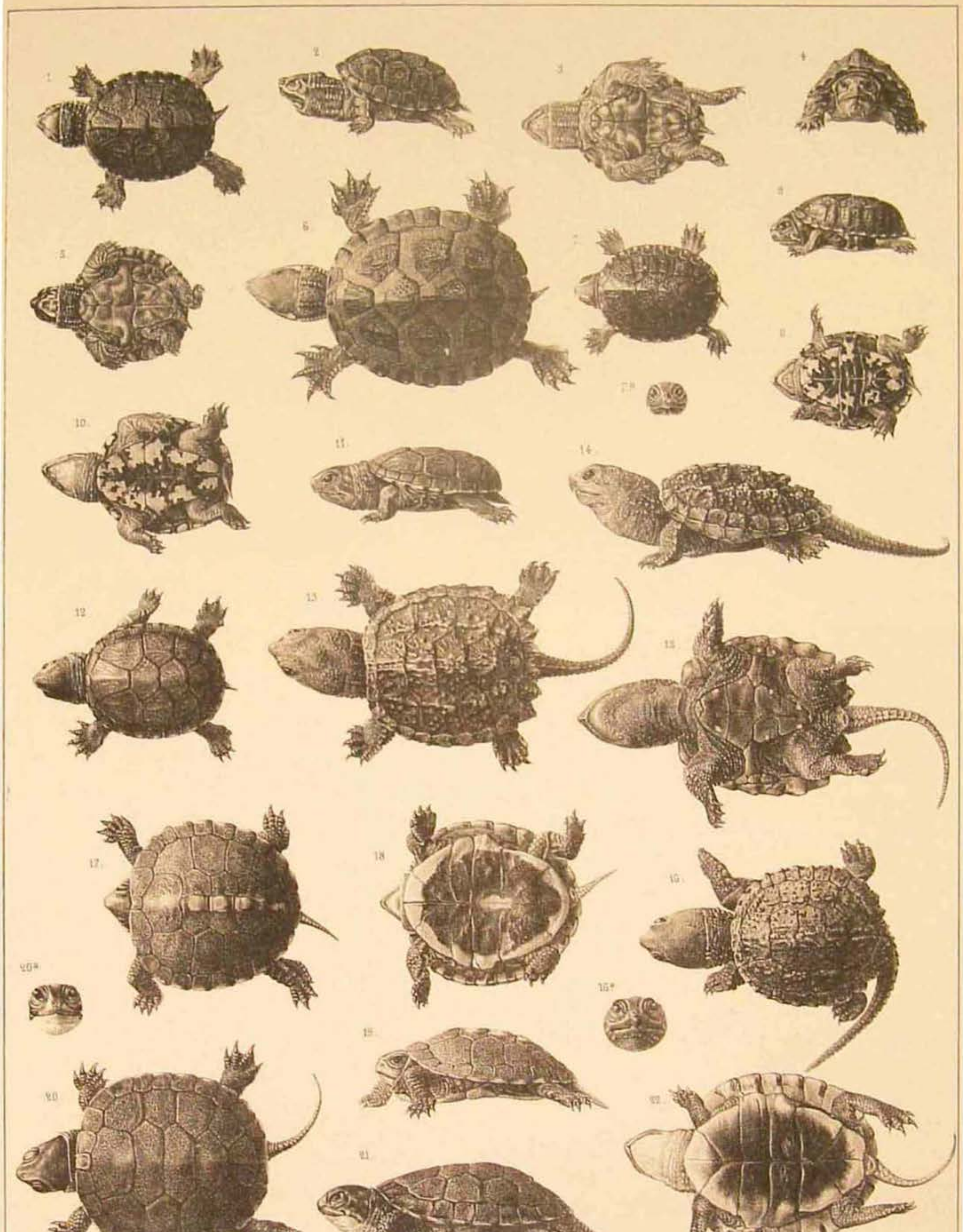
A. Sonrel on stone from nat. L. H. Bradford & Co. print.

1-3. Deirochelys reticulata Ag. — 4-6. Ptychemys concinna Ag. — 7-9. Graptemys geographica Ag.
10-12. Graptemys LeSueurii Ag. — 13-15. Trachemys scabra Ag.



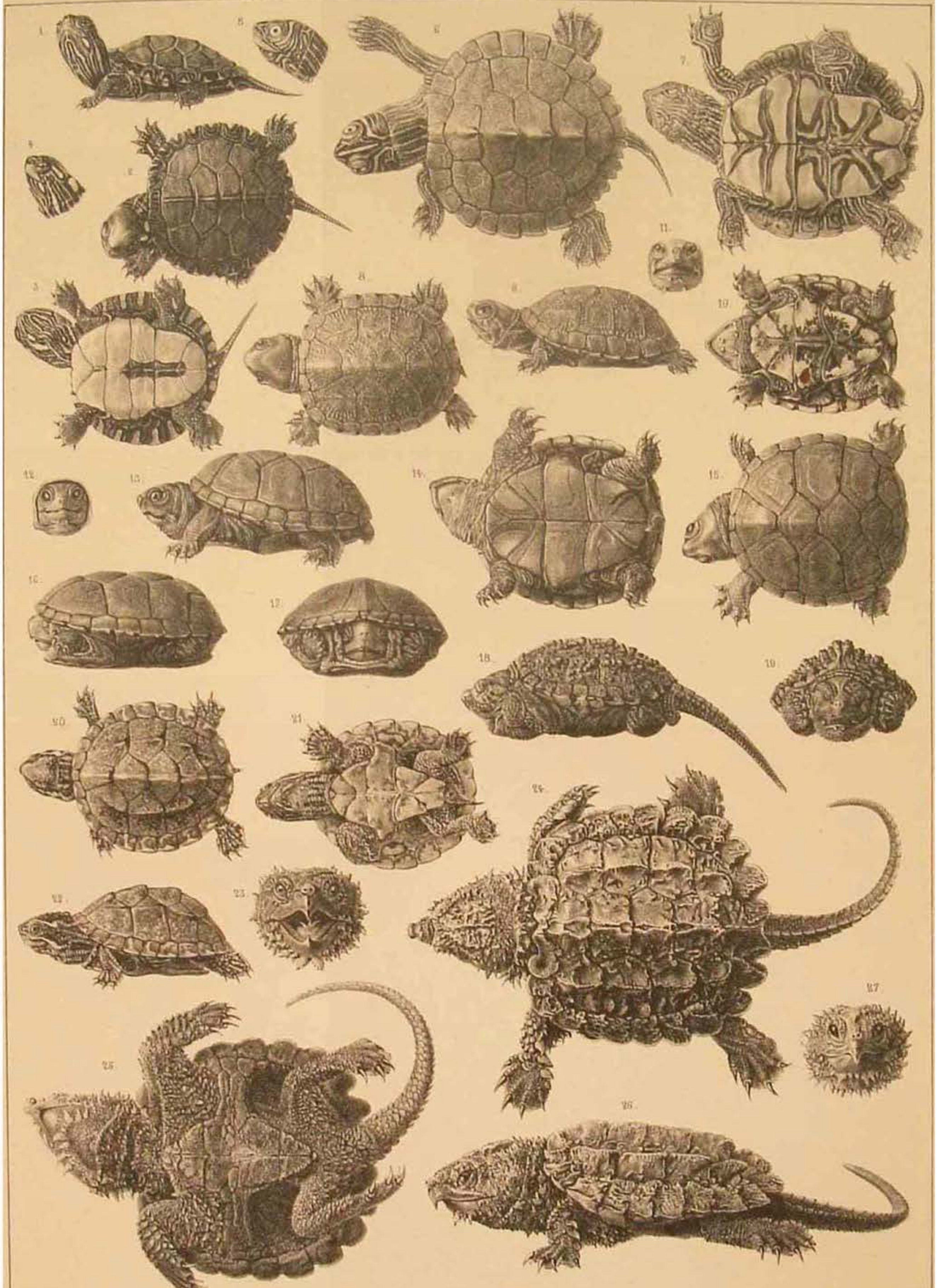
A. Sonrel on stone from nat.l L. H. Bradford & Co. print.

1-3. Chrysemys oregonensis Ag. — 4. Chr. picta Gr. — 5-8. Actinemys marmorata Ag. — 9-11. Trachemys elegans Ag.
12 & 13. Cistudo ornata Ag. — 14-16. Ptychemys mobiliensis Ag. — 17-19. Xerobates Berlandieri Ag.



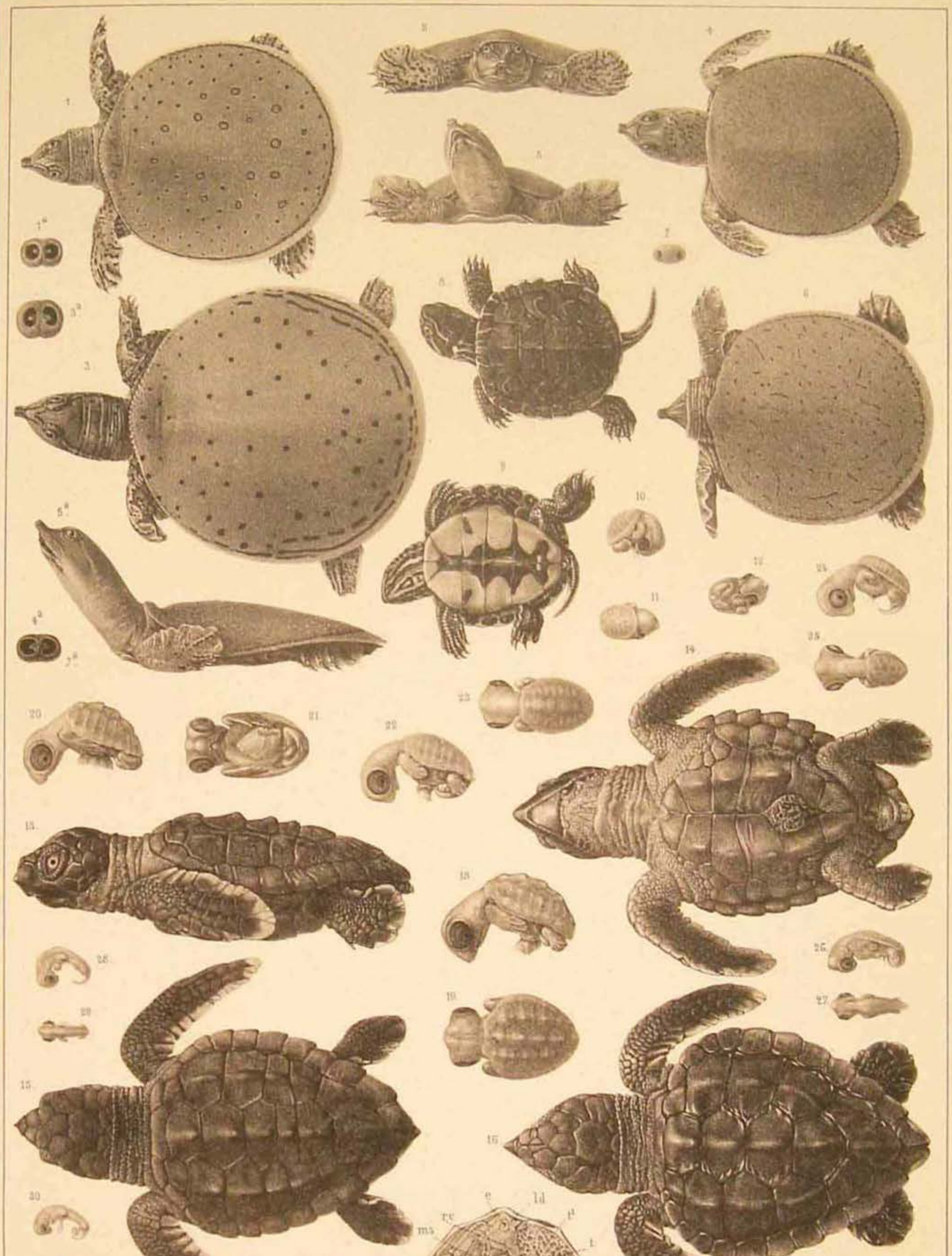
A. Sonrel from nat. on stone. L. H. Bradford & Co. print.

1-6. Ozotheca odorata Ag. — 7-12. Cinosternum pennsylvanicum Bell. — 13-16. Chelydra serpentina Schweig.
17-19. Cistudo virginea Ag. — 20-22. Emys Meleagris Ag.



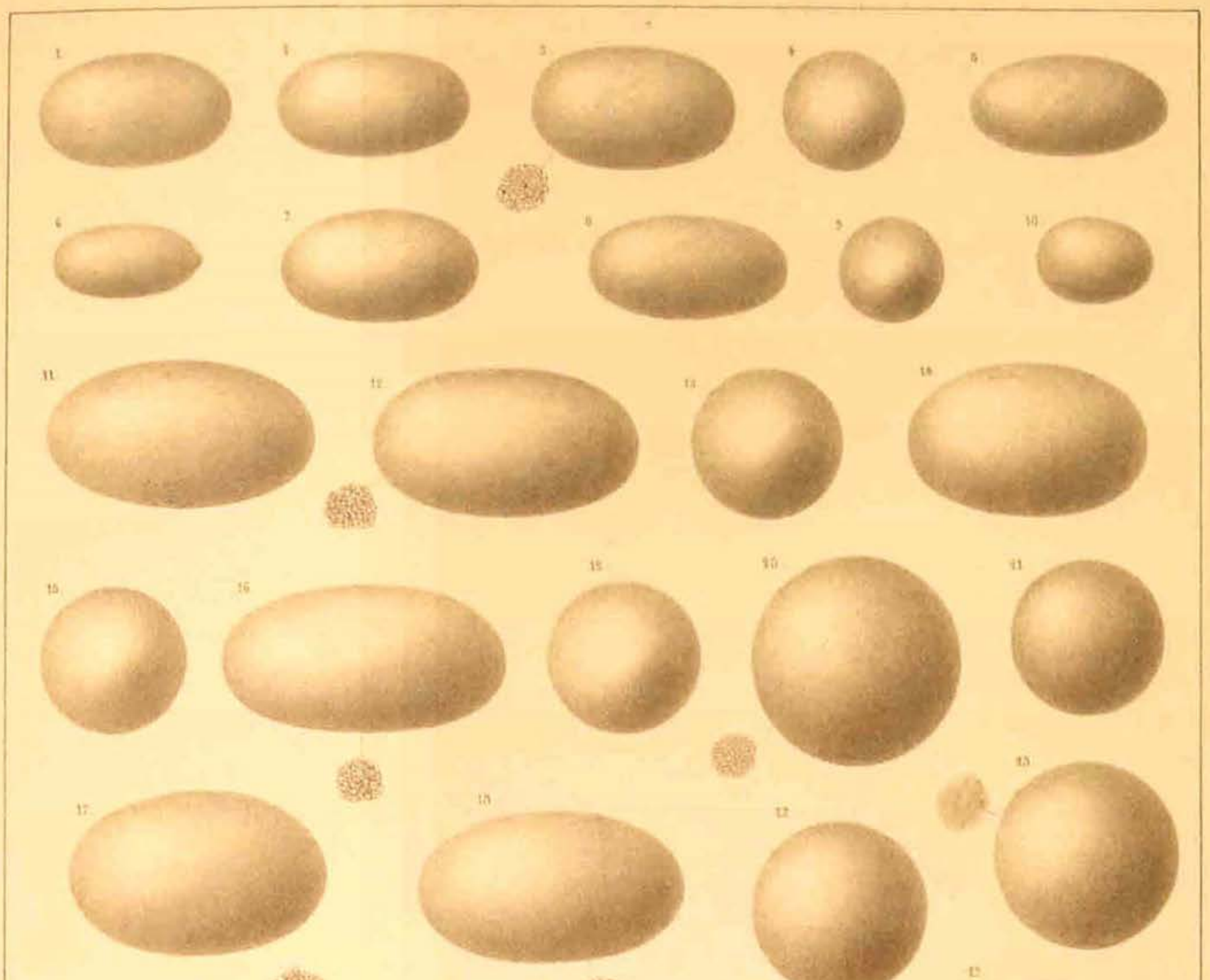
A. Sonrel, from nat' on stone. L. H. Bradford & Co. print.

1-4. CHRYSEMYS MARGINATA Ag. — 5-7. GRAPTEMYS LESUEURII Ag. — 8-11. CINOSTERNUM SONORIENSE LeC.
12-15. CINOSTERNUM FLAVESCENS Ag. — 16, 17. CIN. PENNSYLVANICUM Bell. — 18, 19. CHELYDRA SERPENTINA Schweig.
20-22. OZOTHECA TRISTYCHA Ag. — 23-27. GYPOCHELYS TEMMINCKII Ag.



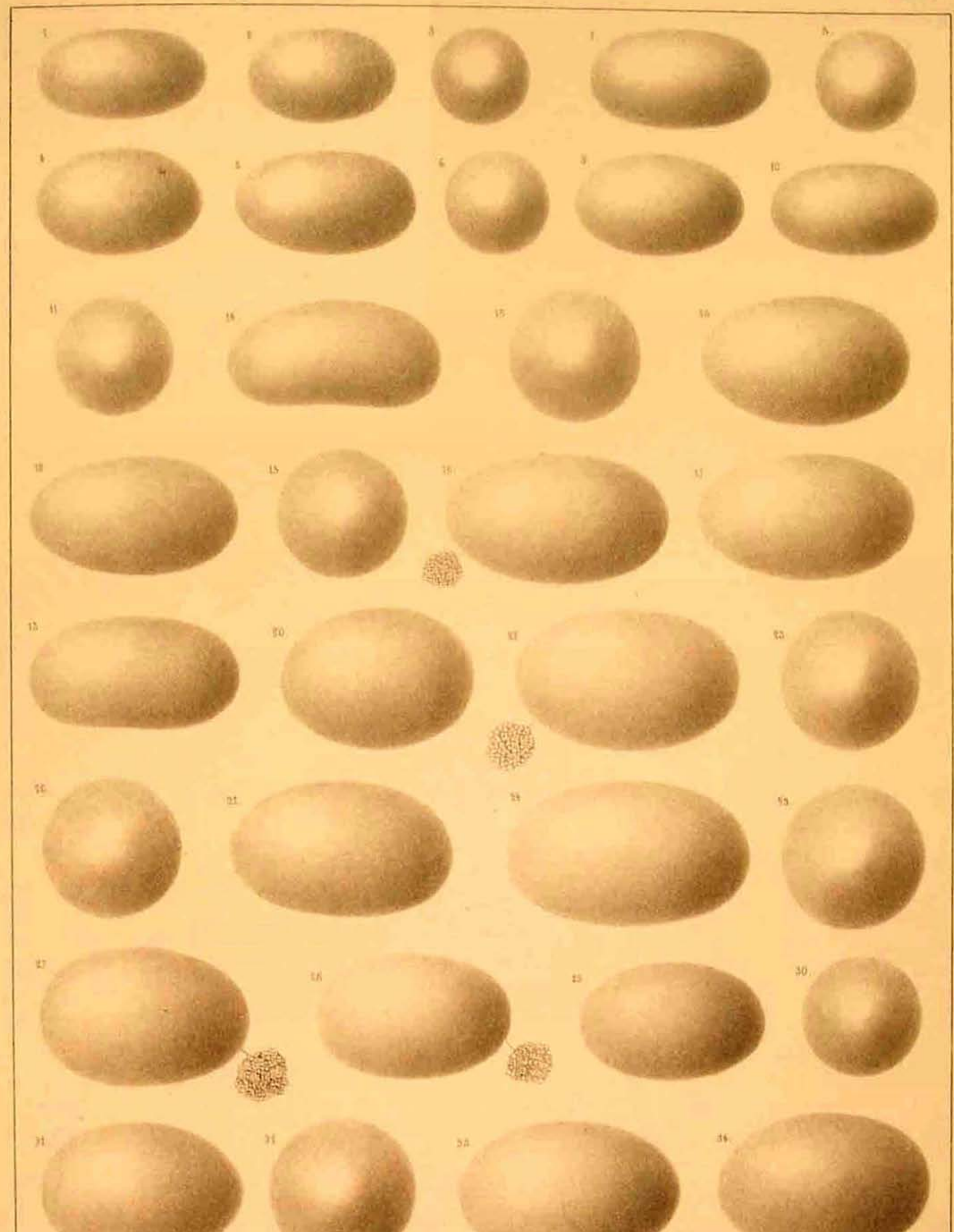
A. Sonrel from nat. on stone — J. H. Bradford & Co. print.

1, 2. Aspidonectes spinifer Ag. — 3. Platypeltis ferox Fitz. — 4, 5. Aspidonectes Emoryi Ag. — 6, 7. Amyda mutica Fitz. 8, 9. Chrysemys Bellii Gray. — 10-12. Ozotheca odorata Ag. — 13-32. Thalassochelys caouana Fitz.



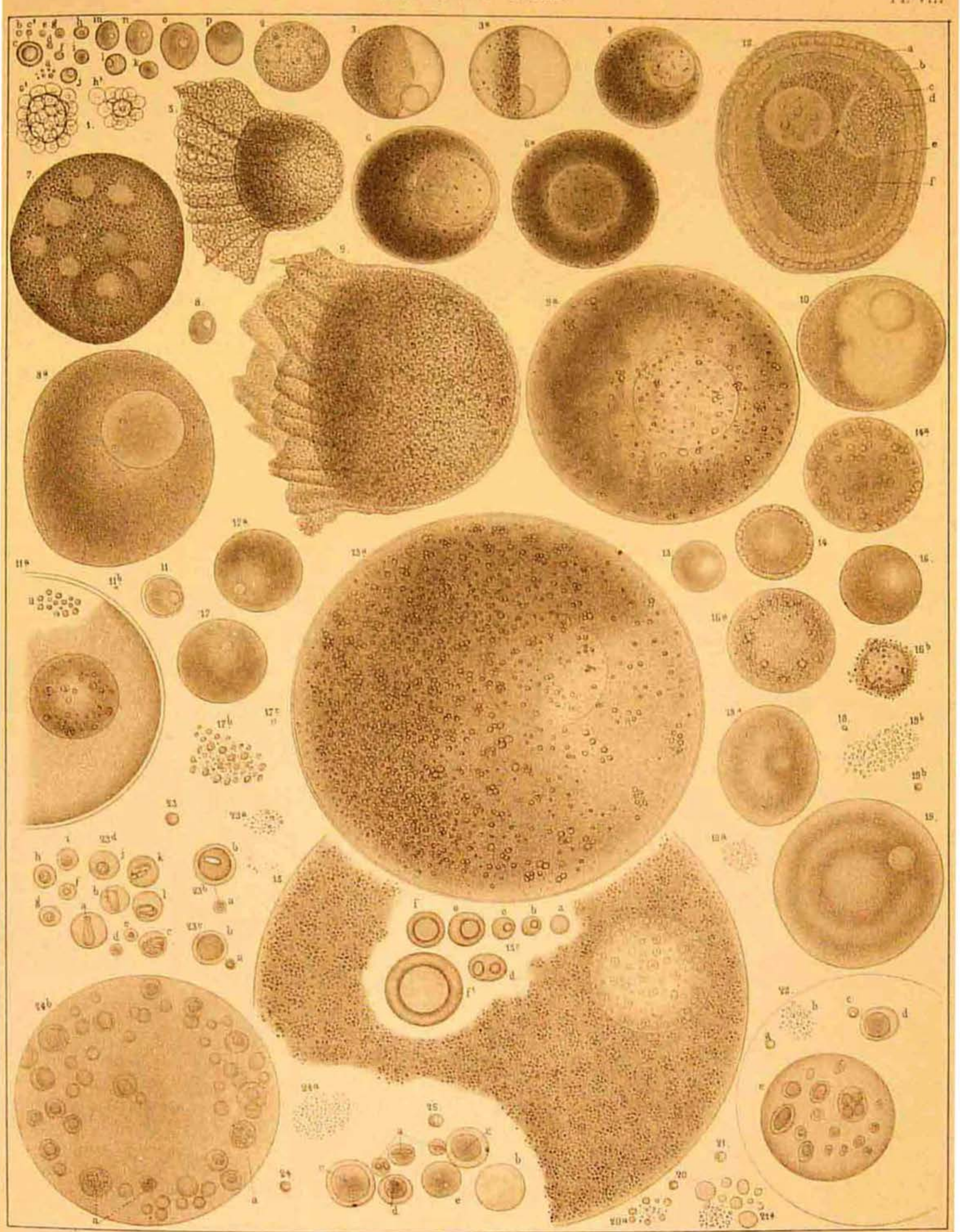
Sonrel & Vogel on stone J. H. Bradford & Co press

1-6. CINOSTERNUM PENNSYLVANICUM Bell — 7-9. OZOTHECA ODORATA Ag — 10-14. CISTUDO VIRGINEA Ag —15, 16. CIS TRIUNGUIS Ag
17-19. DEIROCHELYS RETICULATA Ag — 20. ASPIDONECTES EMORYI Ag — 21. AMYDA MUTICA Fitz — 22. PLATYPELTIS FEROX Fitz.
23. ASPIDONECTES SPINIFER Ag — 24-26. CHELYDRA SERPENTINA Schweig — 27. GYPOCHELYS TEMMINCKII Ag
28, 29. XEROBATES CAROLINUS Ag — 30. THALASSOCHELYS CAOUANA Fitz



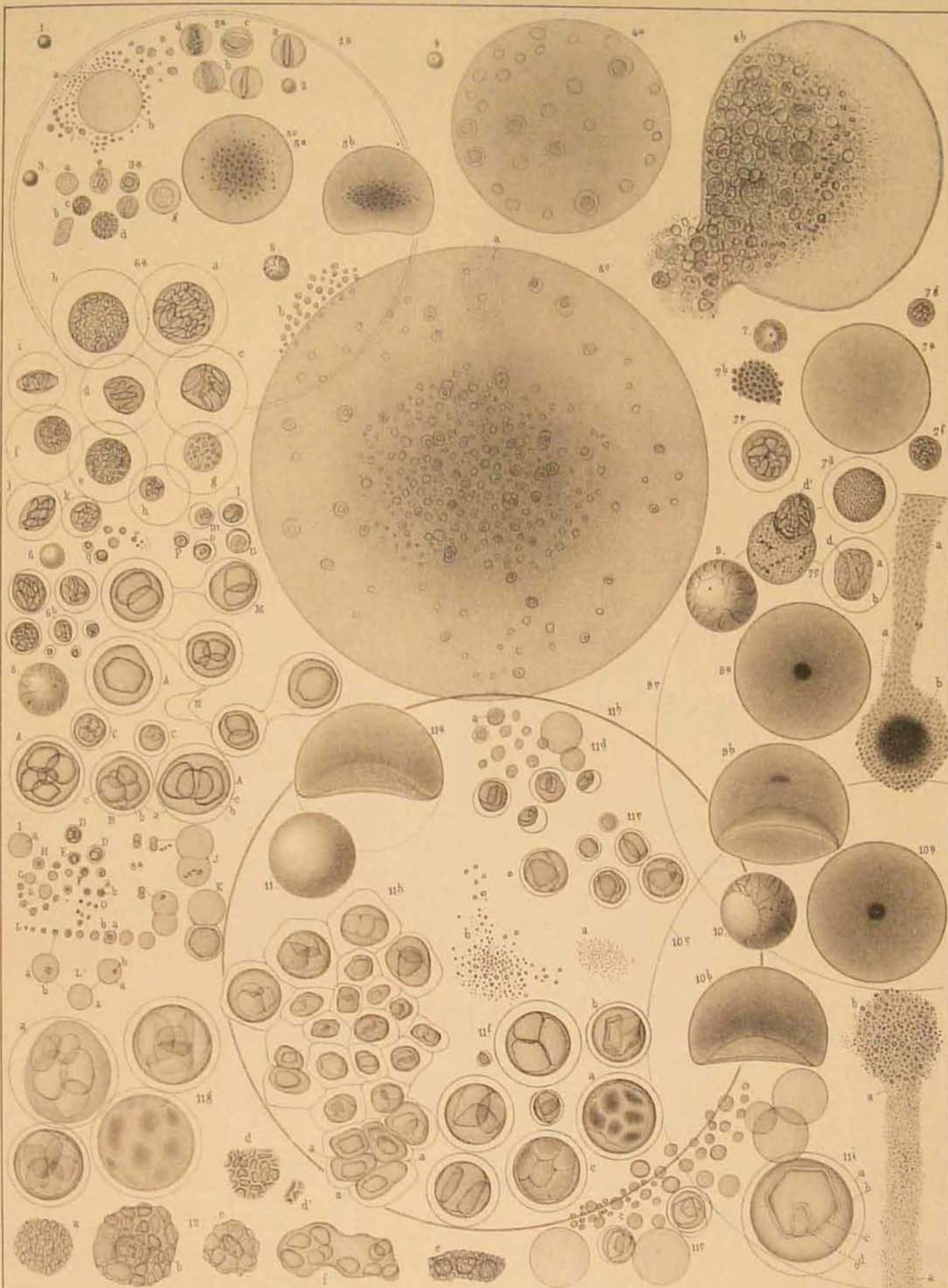
L. H. Bradford & Co. print.

1-3 Chrysemys picta Gr — 4-6 Ch. marginata Ag — 7-10 Nanemys guttata Ag — 11-14 Malacoclemmys palustris Ag.
15-17 Glyptemys insculpta Ag — 18, 19 Trachemys elegans Ag — 20-23 Ptychemys concinna Ag — 24, 25 Pt. mobiliensis Ag
26, 27 Emys Meleagris Ag — 28-30 Graptemys geographica Ag — 31-34 Gr. LeSueurii Ag



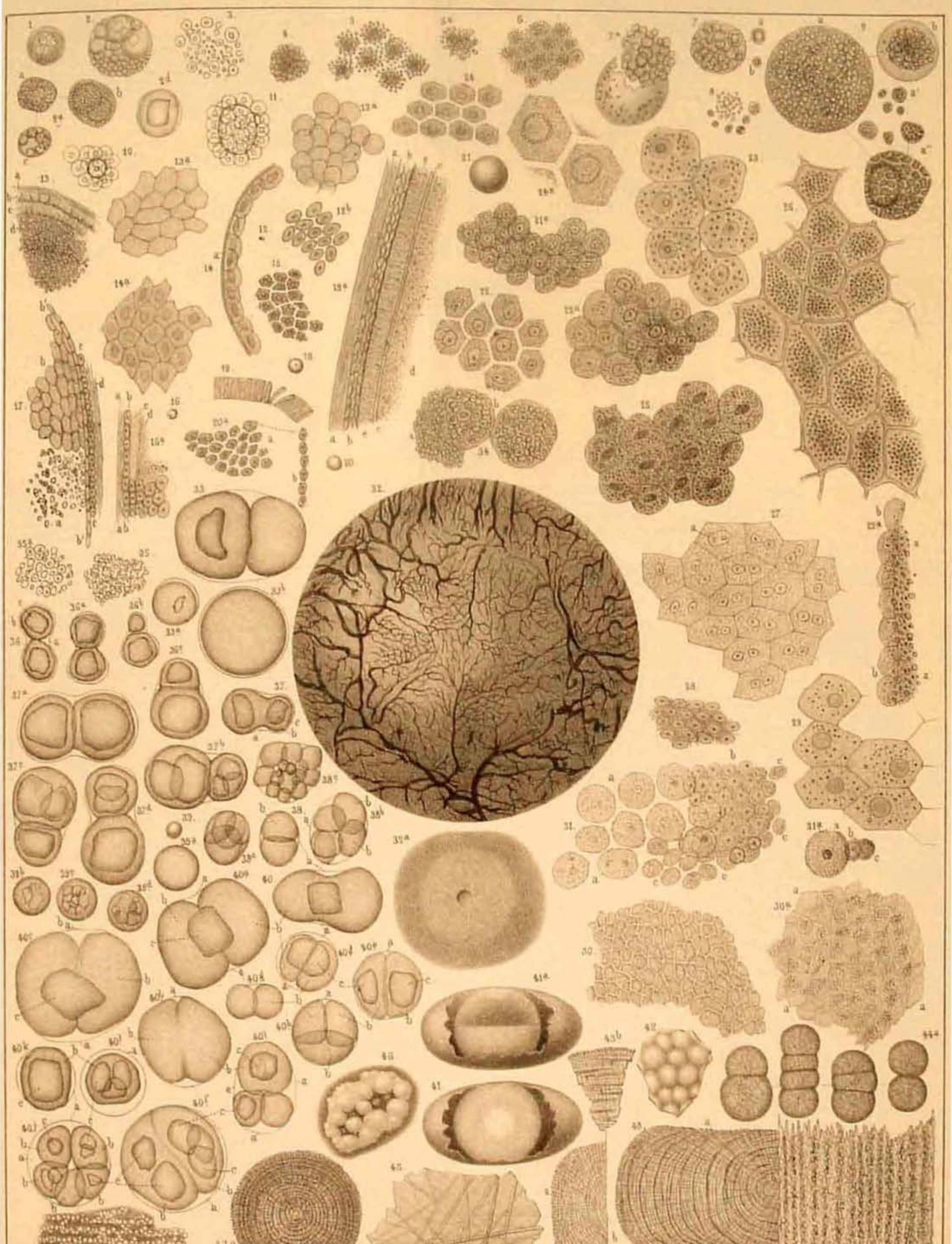
Clark from nat. Sonrel on stone. H. L. Bradford & Co. print.

OVARIAN EGGS.



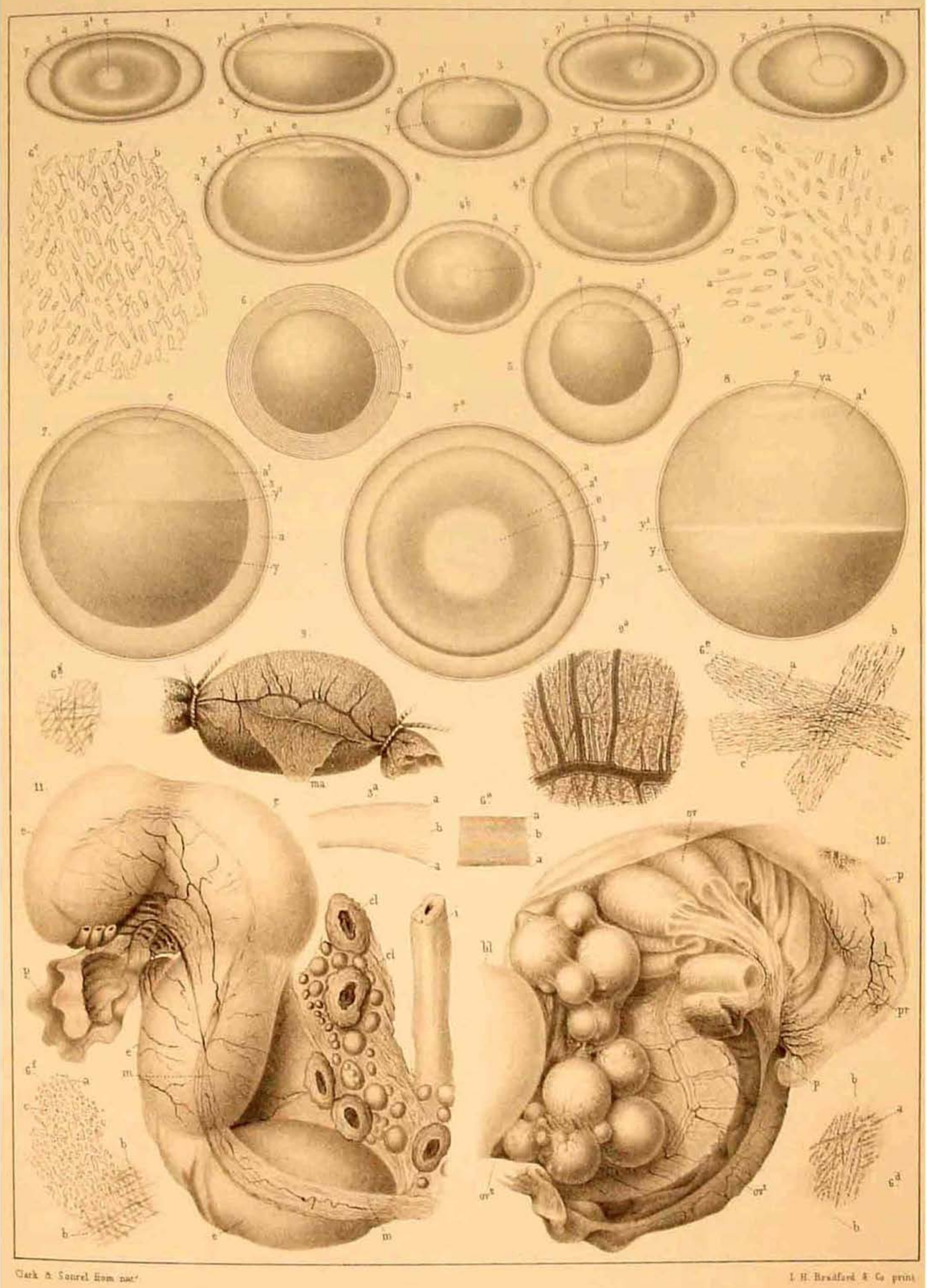
Clark from nat. Ibbotson on stone. L. H. Bradford & Co. print.

OVARIAN EGGS.



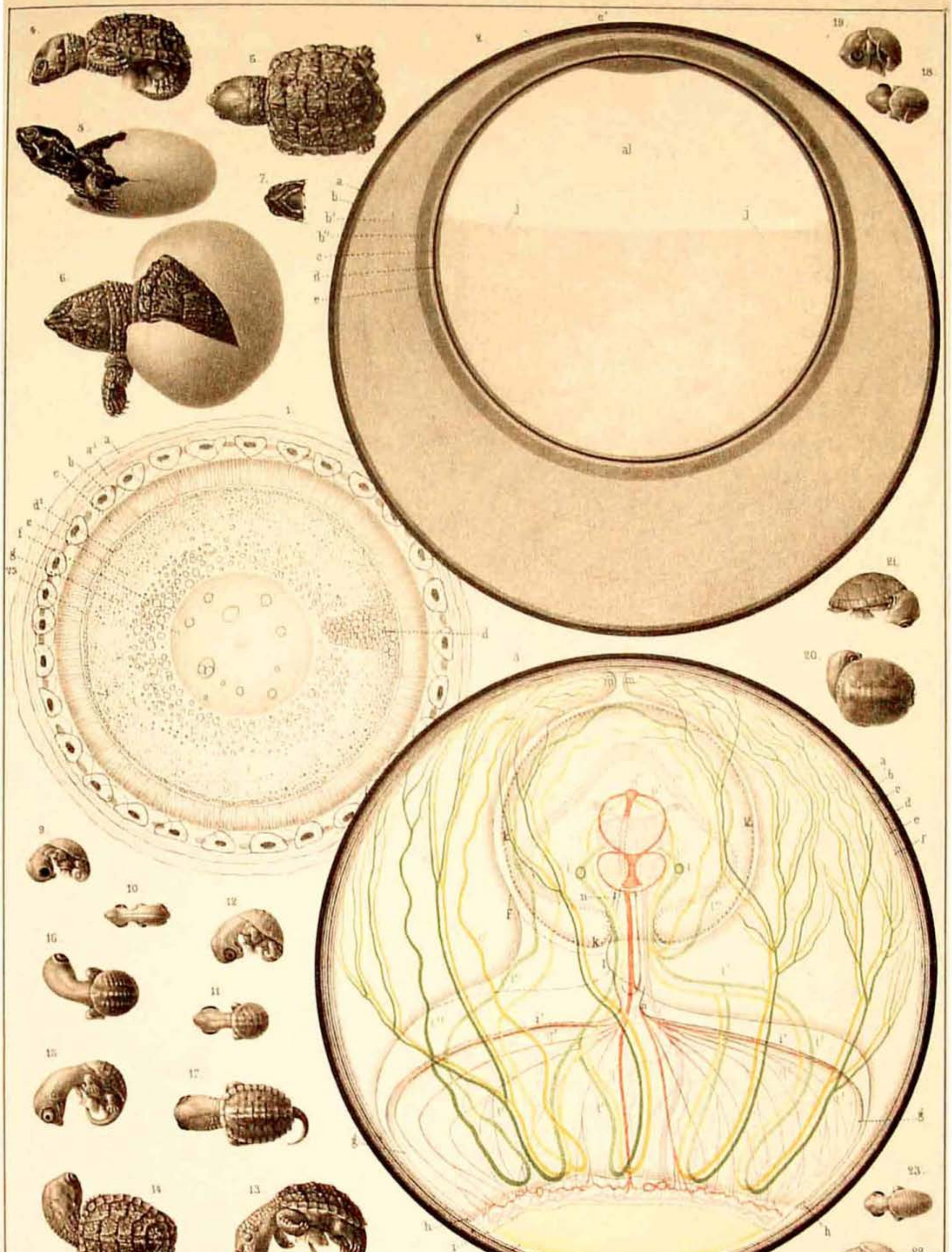
Clark from nat. Ibbotson on stone L. H. Bradford & Co. print.

OVARIAN EGGS AND EGG SHELLS



Clark & Sonrel from nat. J. H. Bradford & Co. print.

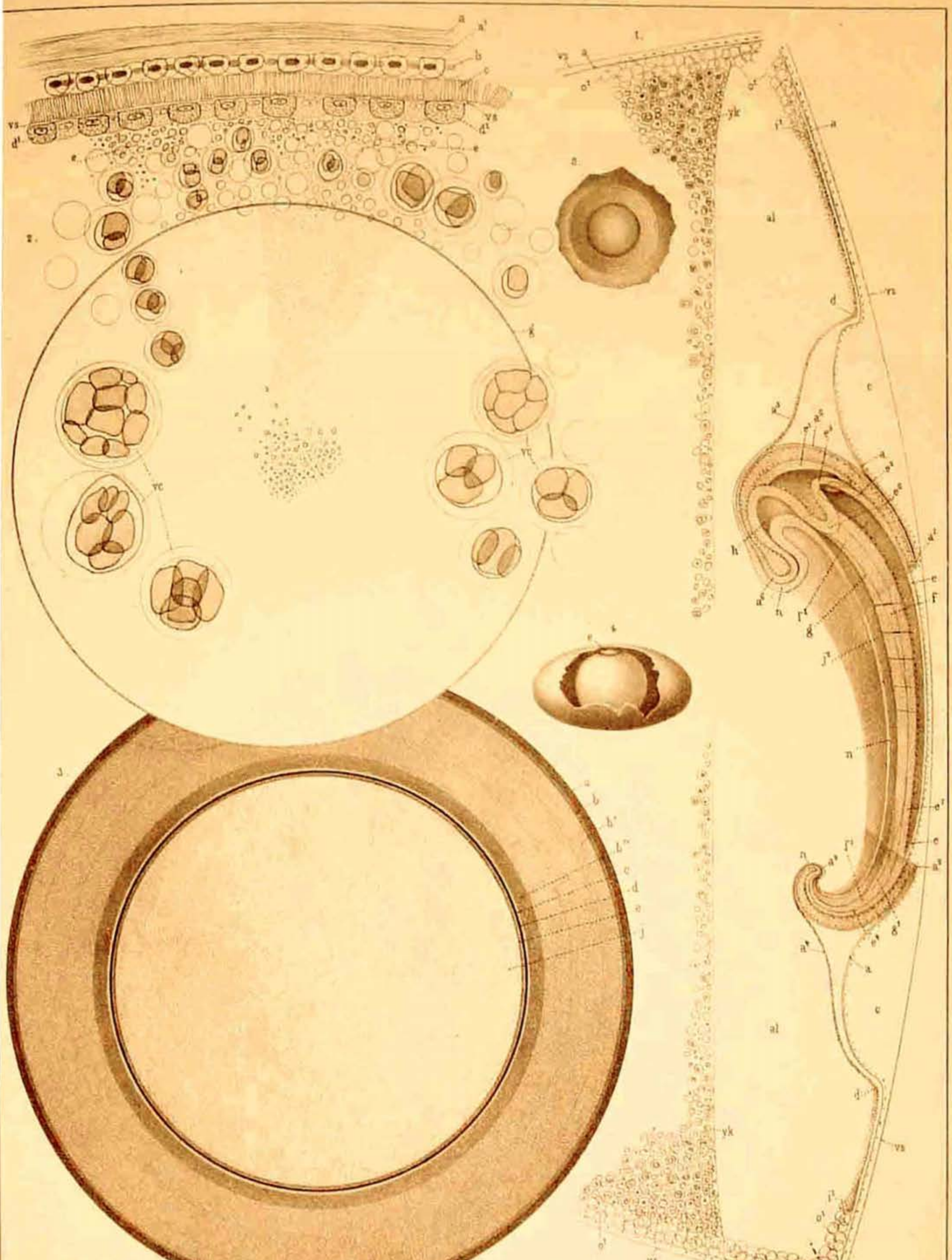
THE OVARY & OVIDUCT AND THE ABSORPTION OF THE ALBUMEN



Clark & Sonrel from nat.

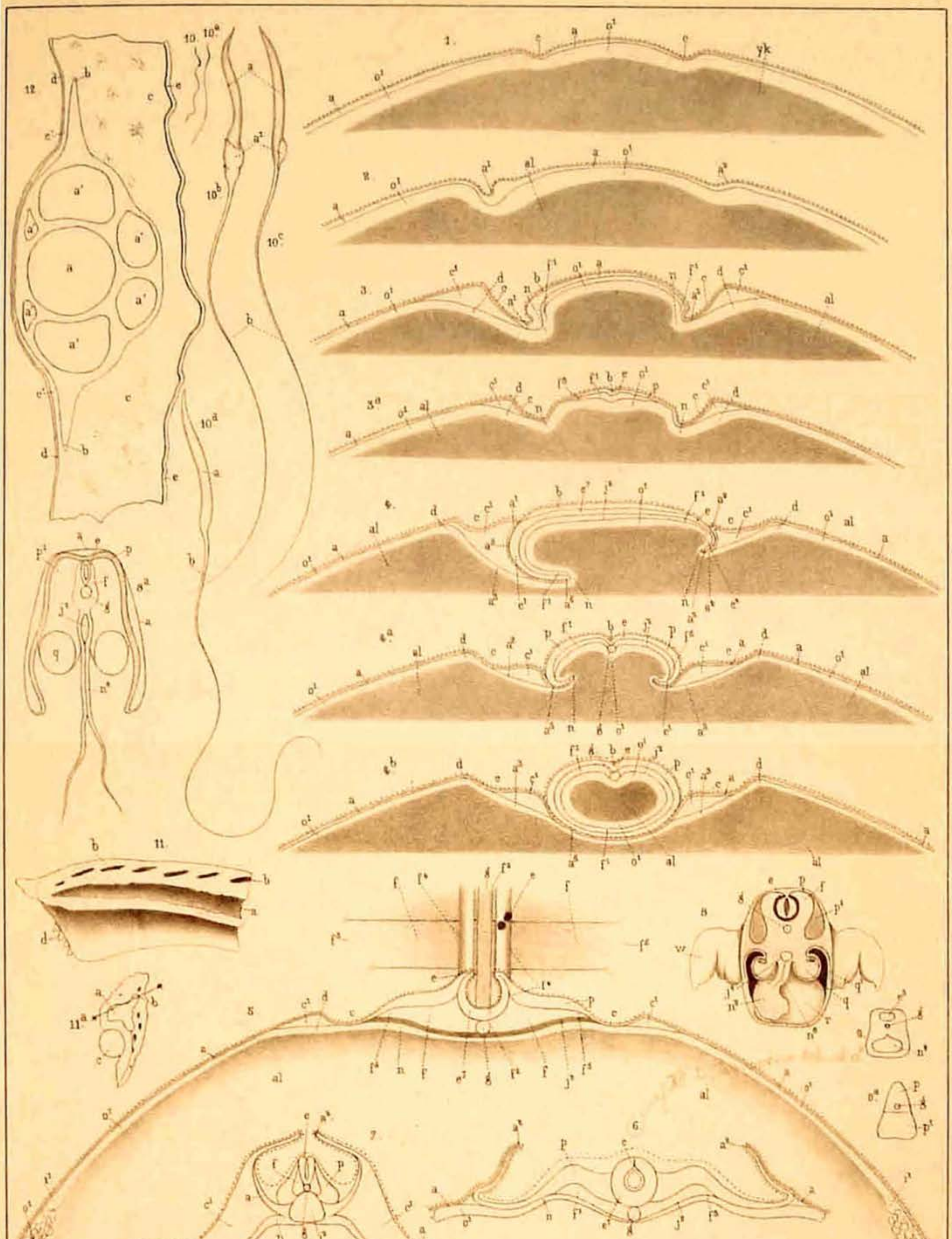
L. H. Bradford & Co. print

DIAGRAMS OF THE EGG & EMBRYOS OF CHELYDRA SERPENTINA, OZOTHECA ODORATA AND CHRYSEMYS PICTA



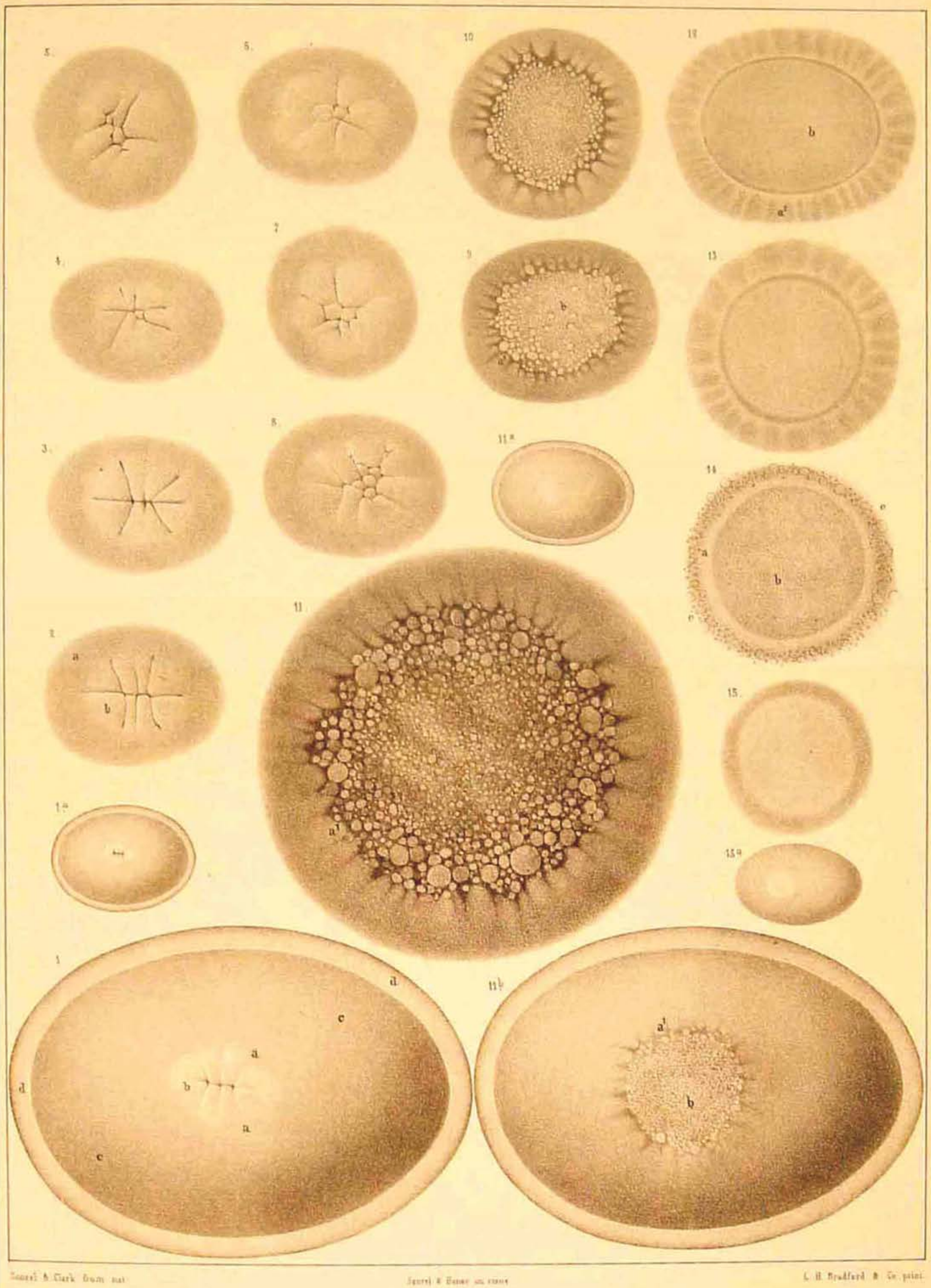
Clark from nat. L. H. Bradford & Co. print

SECTIONS OF THE EGG AND OF THE EMBRYO



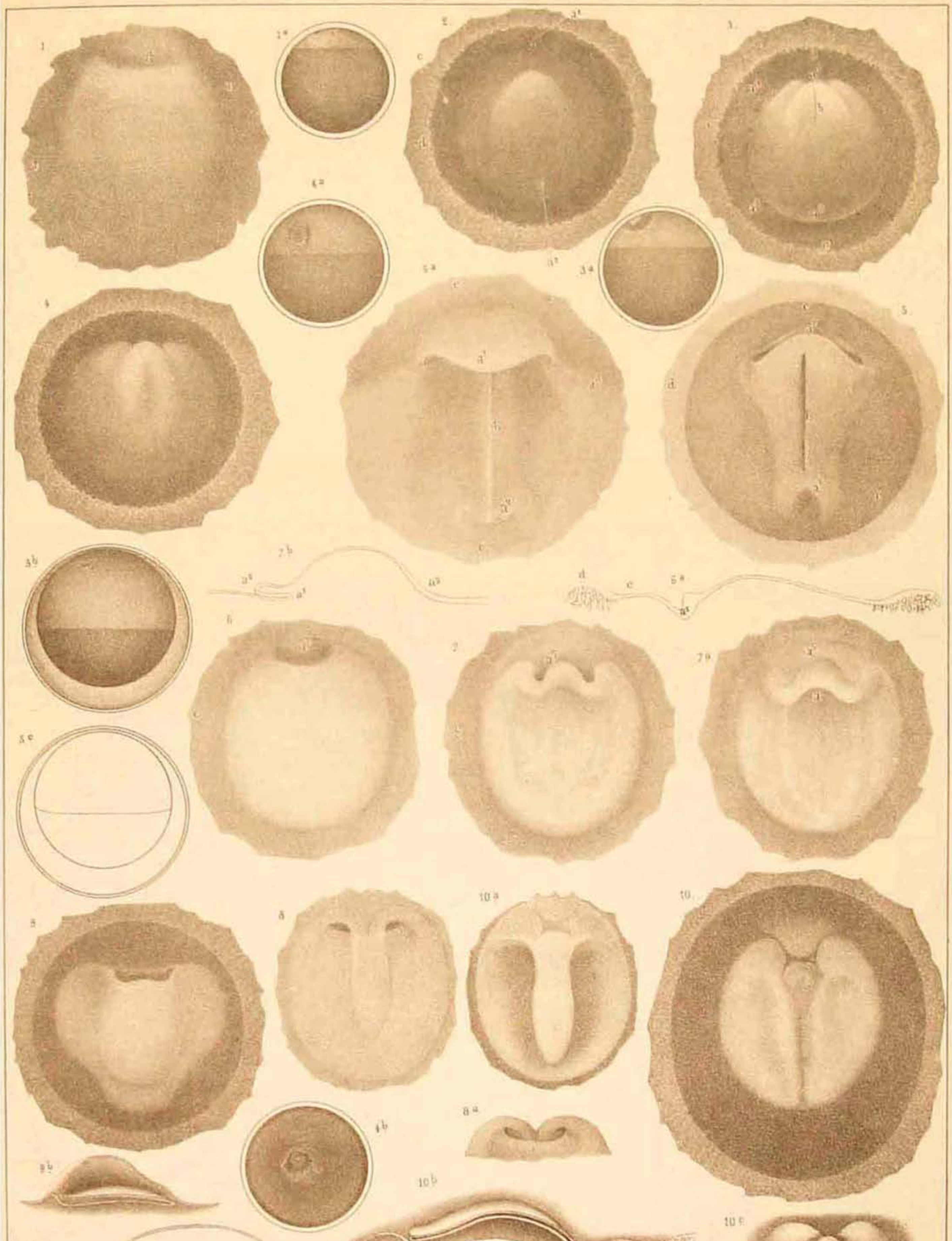
Clark from nat. L. H. Bradford & Co. print.

SECTIONS AND SPERMATIC PARTICLES.



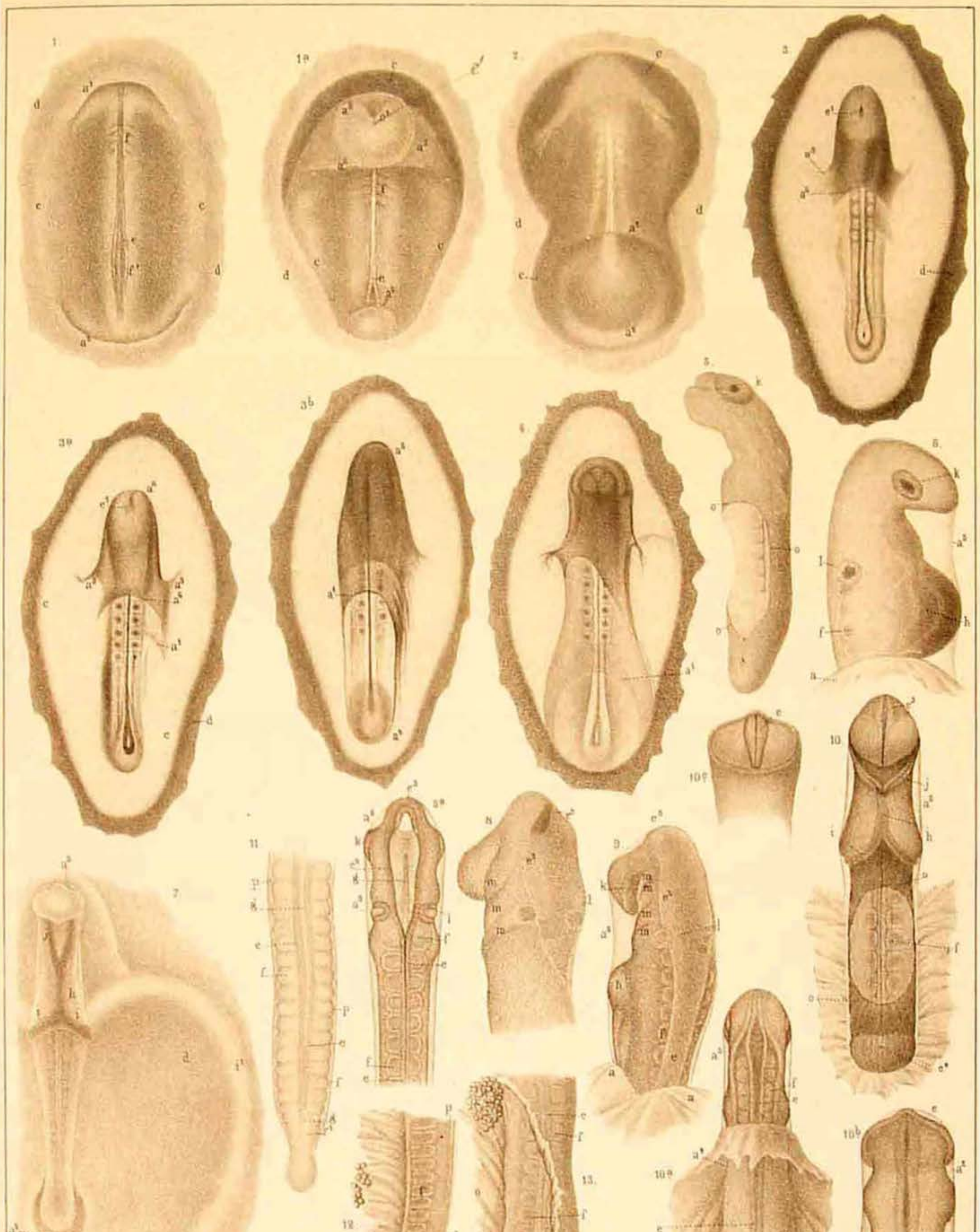
Sonrel & Clark from nat. Sonrel & Bauer on stone L. H. Bradford & Co. print.

SEGMENTATION OF THE YOLK



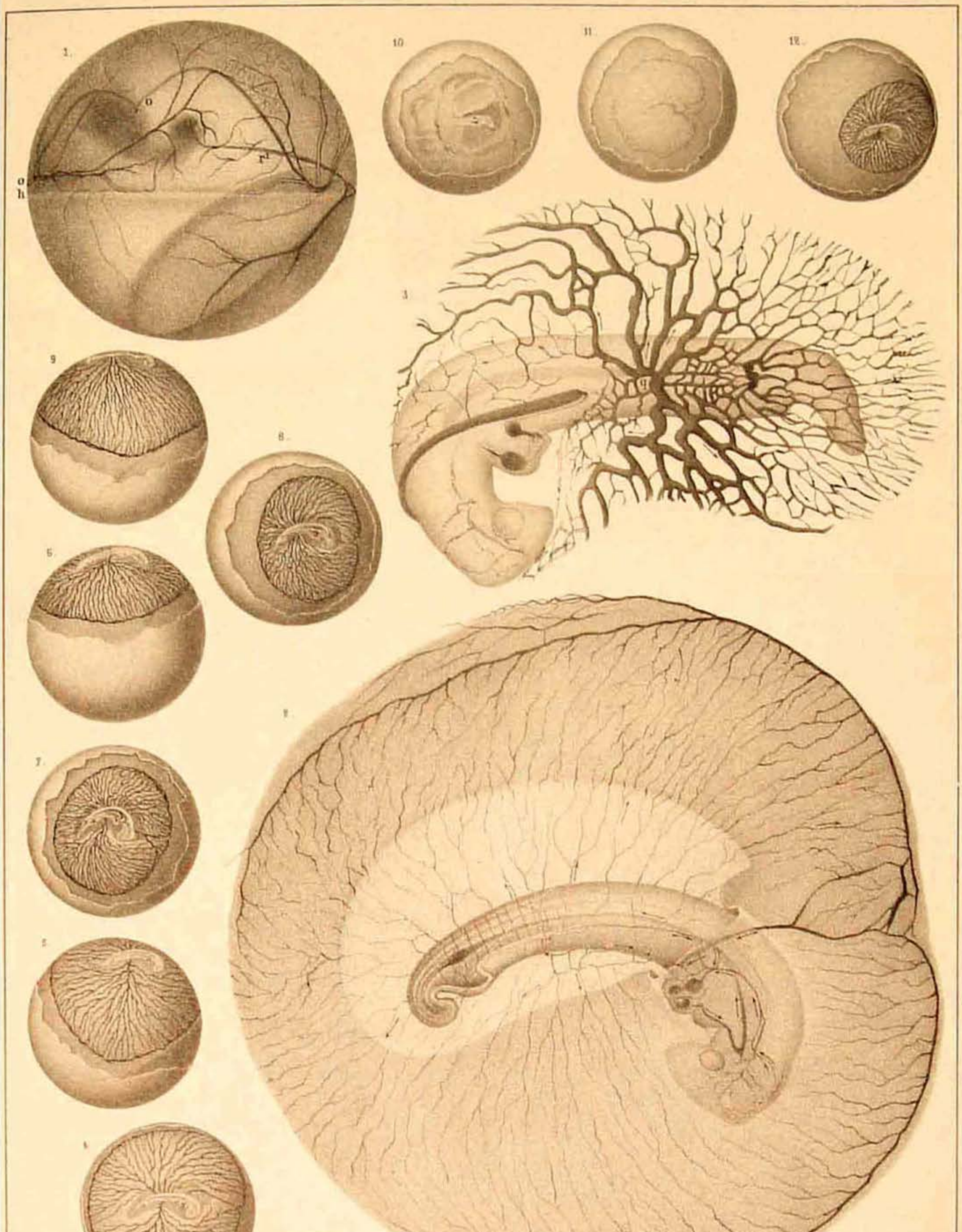
Clark & Sonrel from nat. H. J. Ibbotson on stone. L. H. Bradford & Co print.

FOLDING OF THE BLASTODERMA



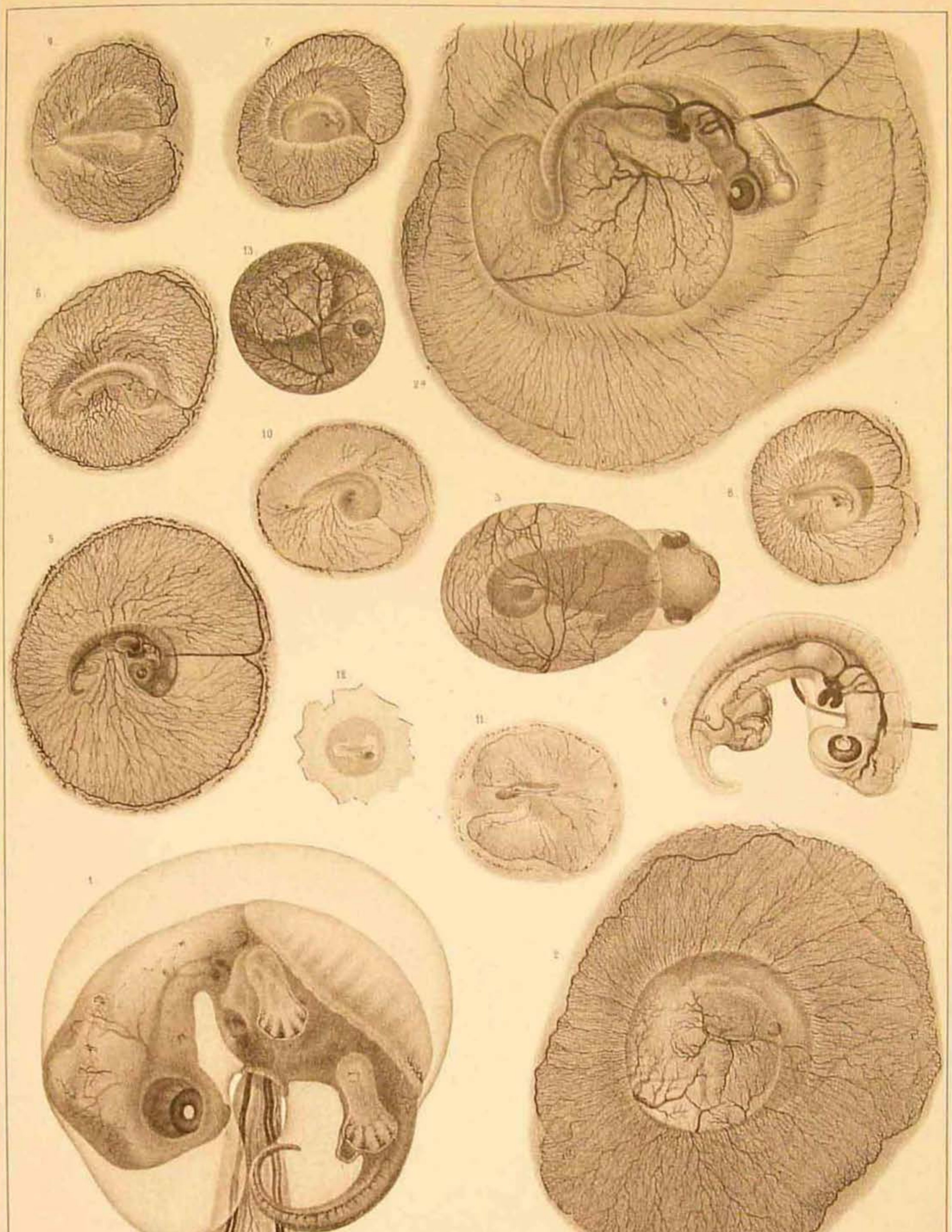
Clark & Sonrel from nat. L. H. Bradford & Co. print.

FORMATION OF THE AXIS OF THE BODY



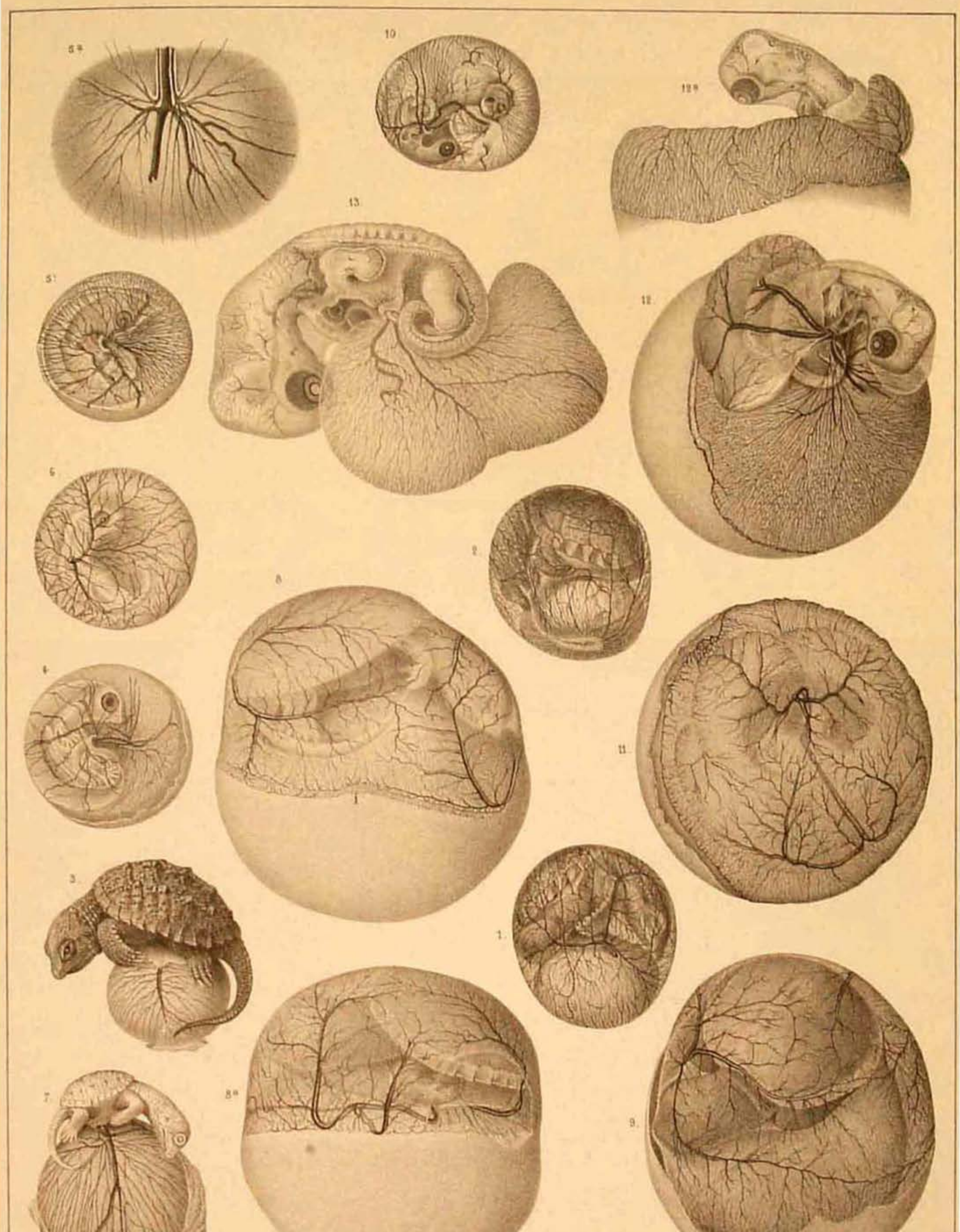
A. Sonrel from nat. A. J. Ibbotson on stone L. H. Bradford & Co. print.

VITELLINE AND ALLANTOIDIAN CIRCULATION.



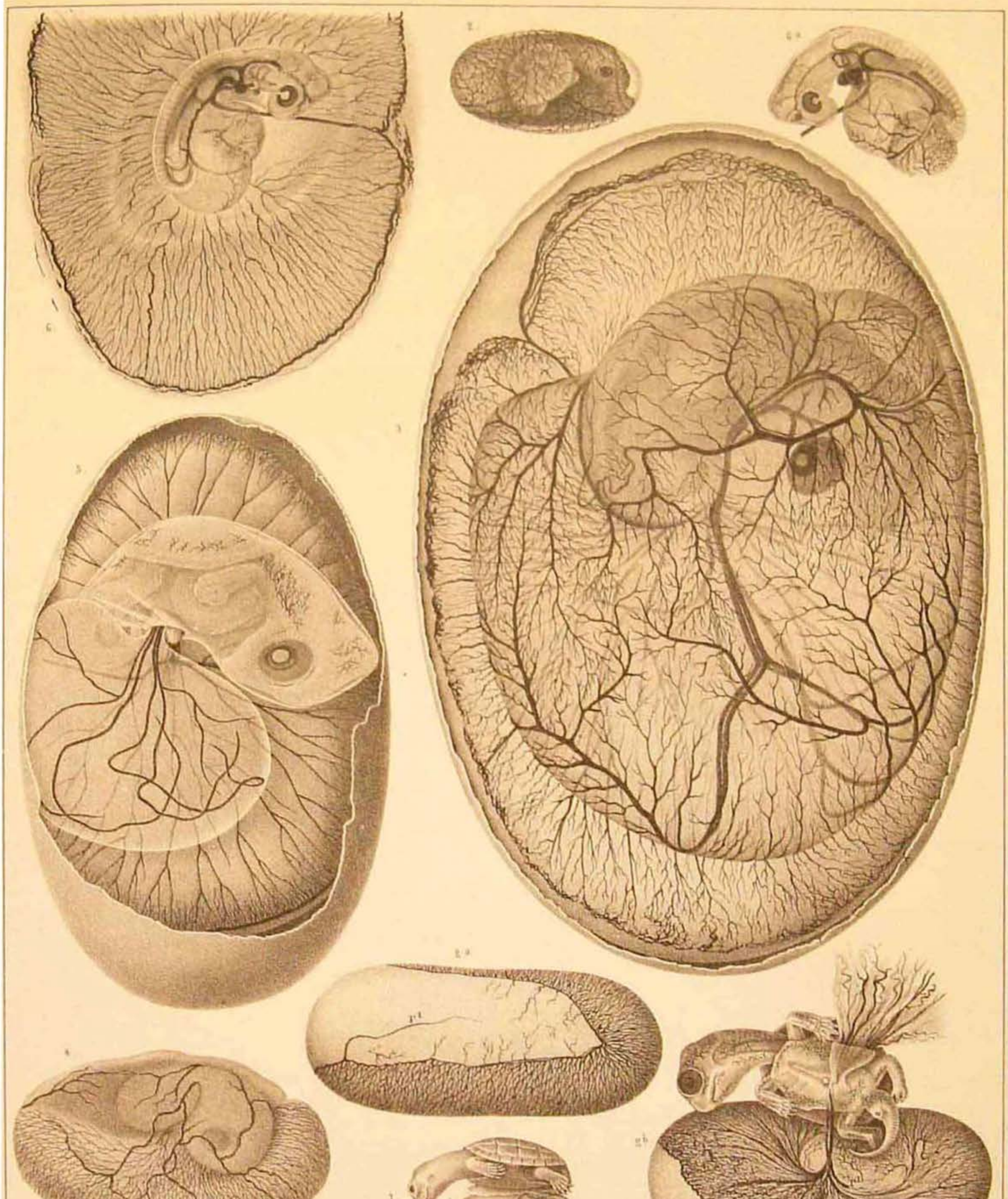
Sonrel & Clark from nat.^e A. Sonrel on stone. L. H. Bradford & Co. print.

VITELLINE AND ALLANTOIDIAN CIRCULATION



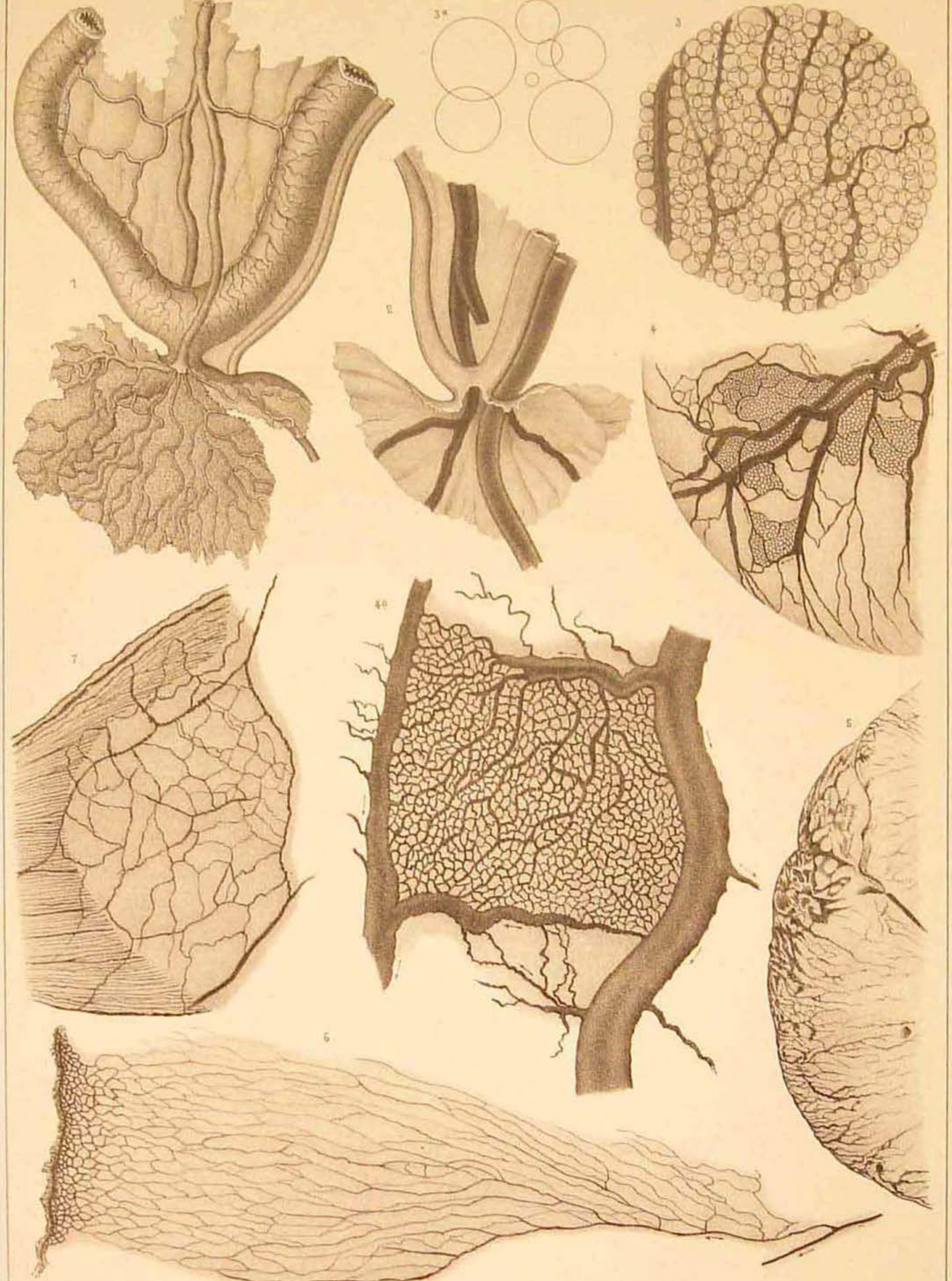
A. Sonrel from nat. A. J. Ibbotson on stone L. H. Bradford & Co. print.

VITELLINE AND ALLANTOIDIAN CIRCULATION



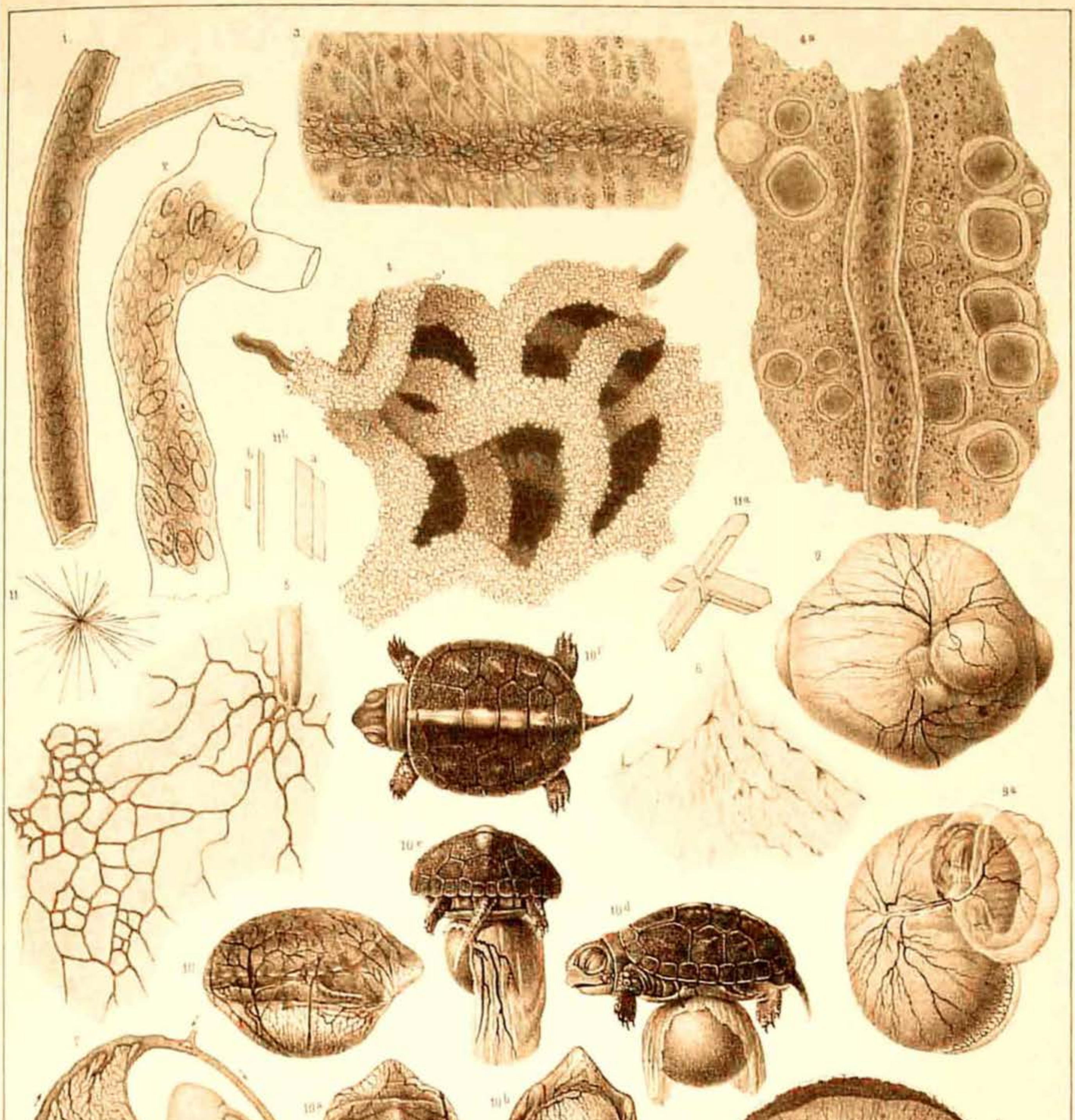
Sonrel & Clark from nat. Sonrel on stone. J. H. Bradford & Co. print.

VITELLINE AND ALLANTOIDIAN CIRCULATION.



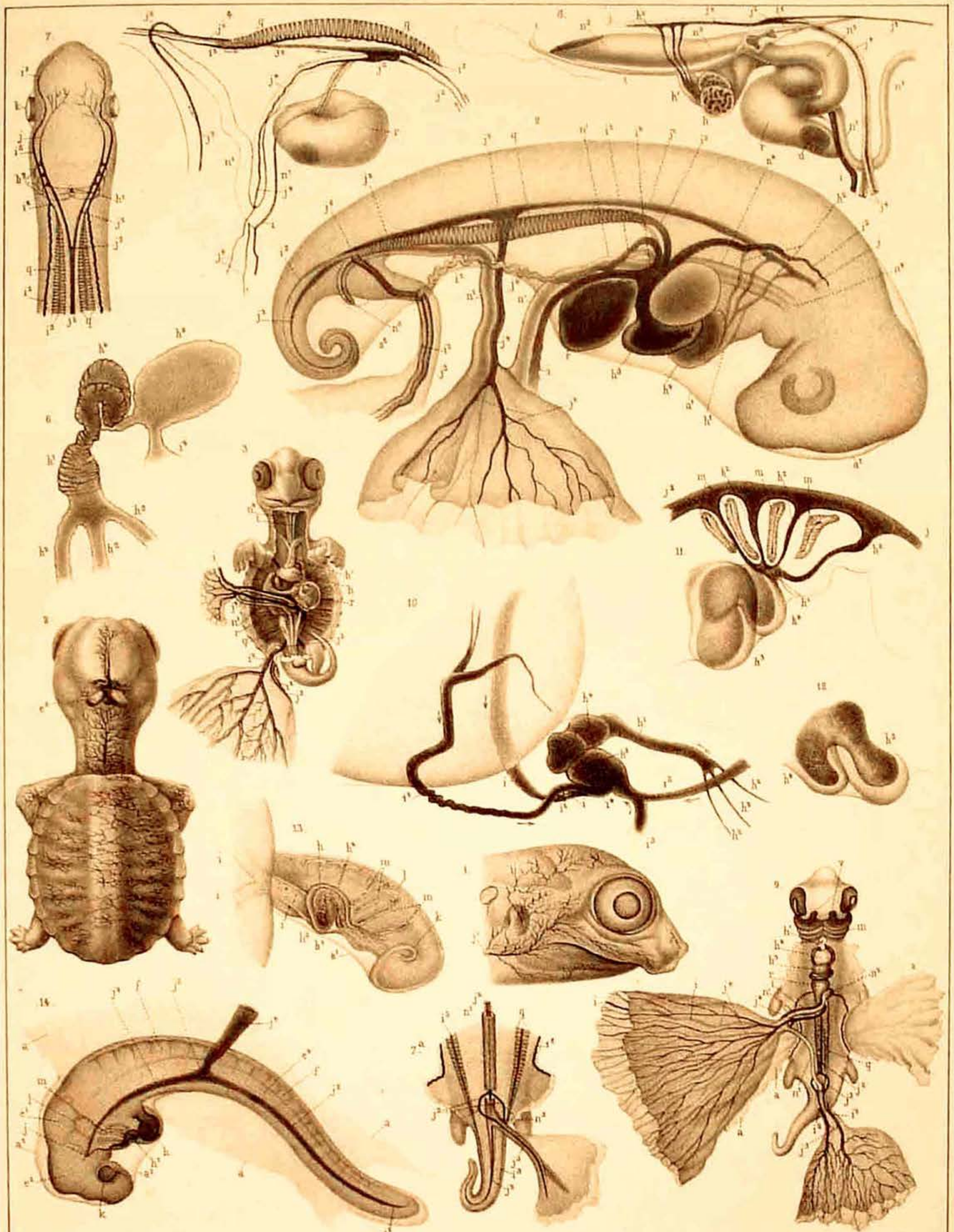
Clark & Sonrel from nat. A. J. Ibbotson on stone. L. H. Bradford & Co print.

DETAILS OF CIRCULATION.



Sonrel & Clark from nat. A. Sonrel on stone L. H. Bradford & Co. print

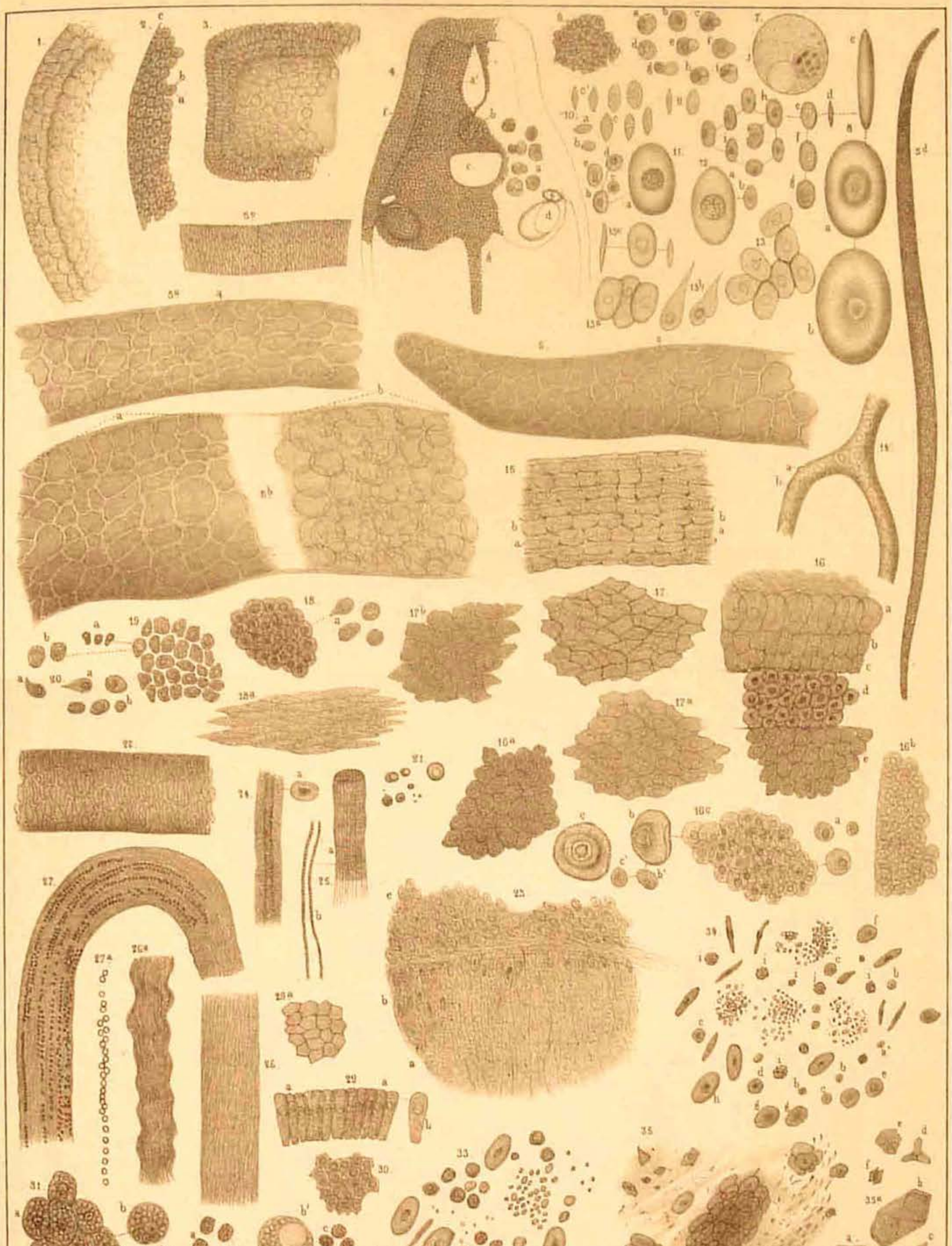
VITELLINE AND ALLANTOIDIAN CIRCULATION



Clark & Sonrel from nat.

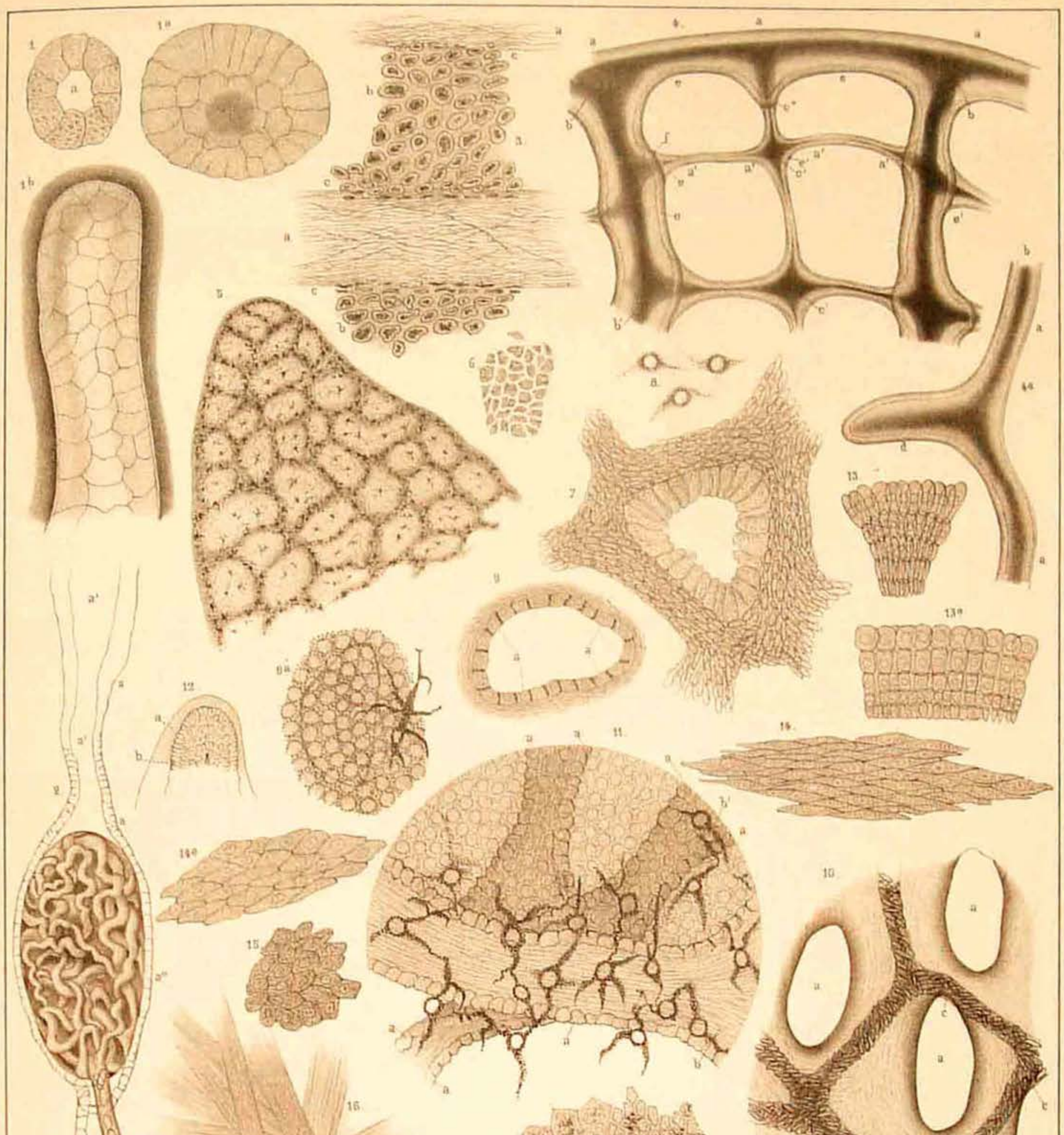
L. H. Bradford & Co. print.

INTERNAL CIRCULATION



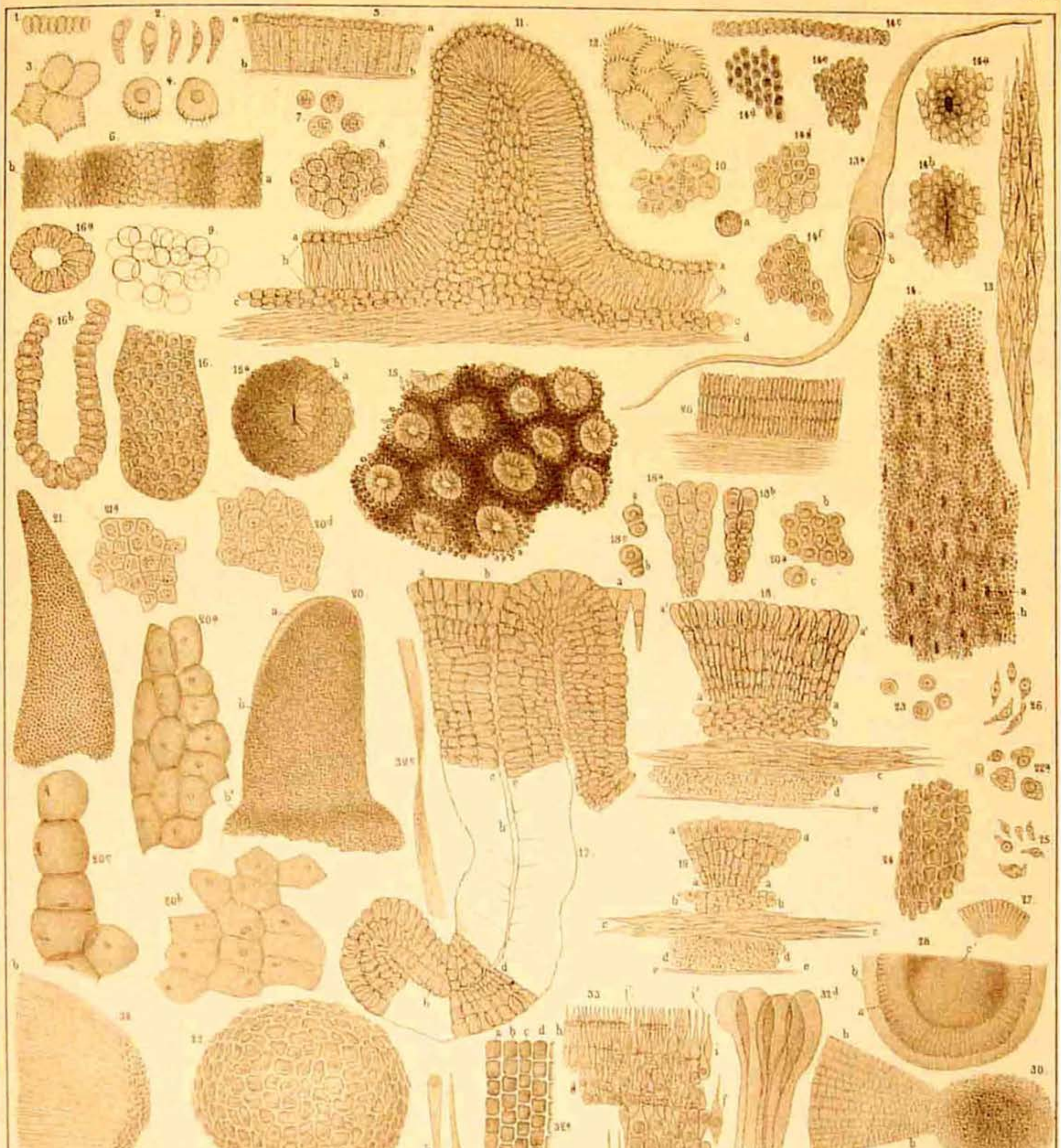
Clark from nat. Sibotson on stone. L. H. Bradford & Co. print.

HISTOLOGY.



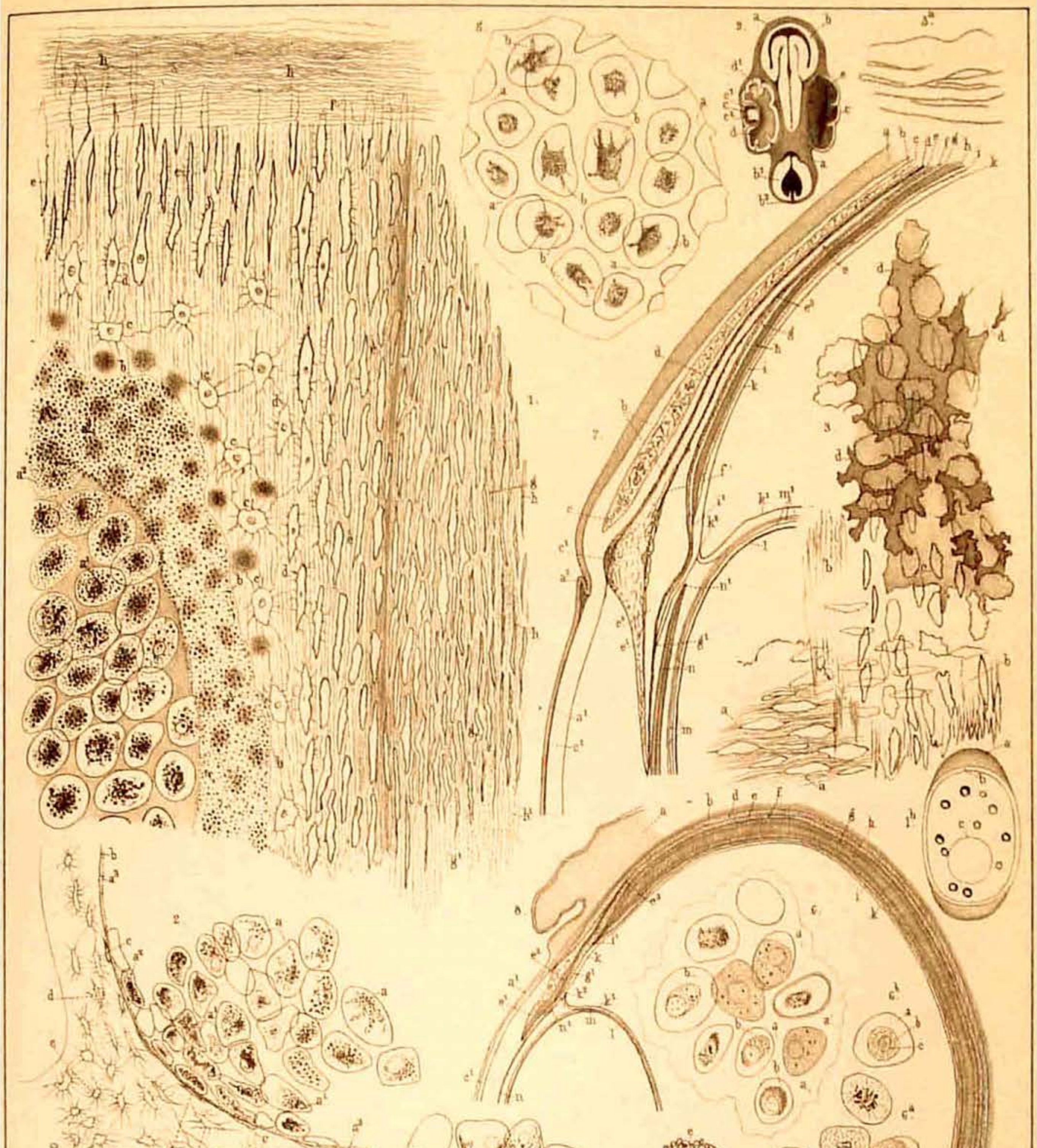
H.J. Clark from nat. Ibbotson on stone L.H. Bradford & Co print.

HISTOLOGY.



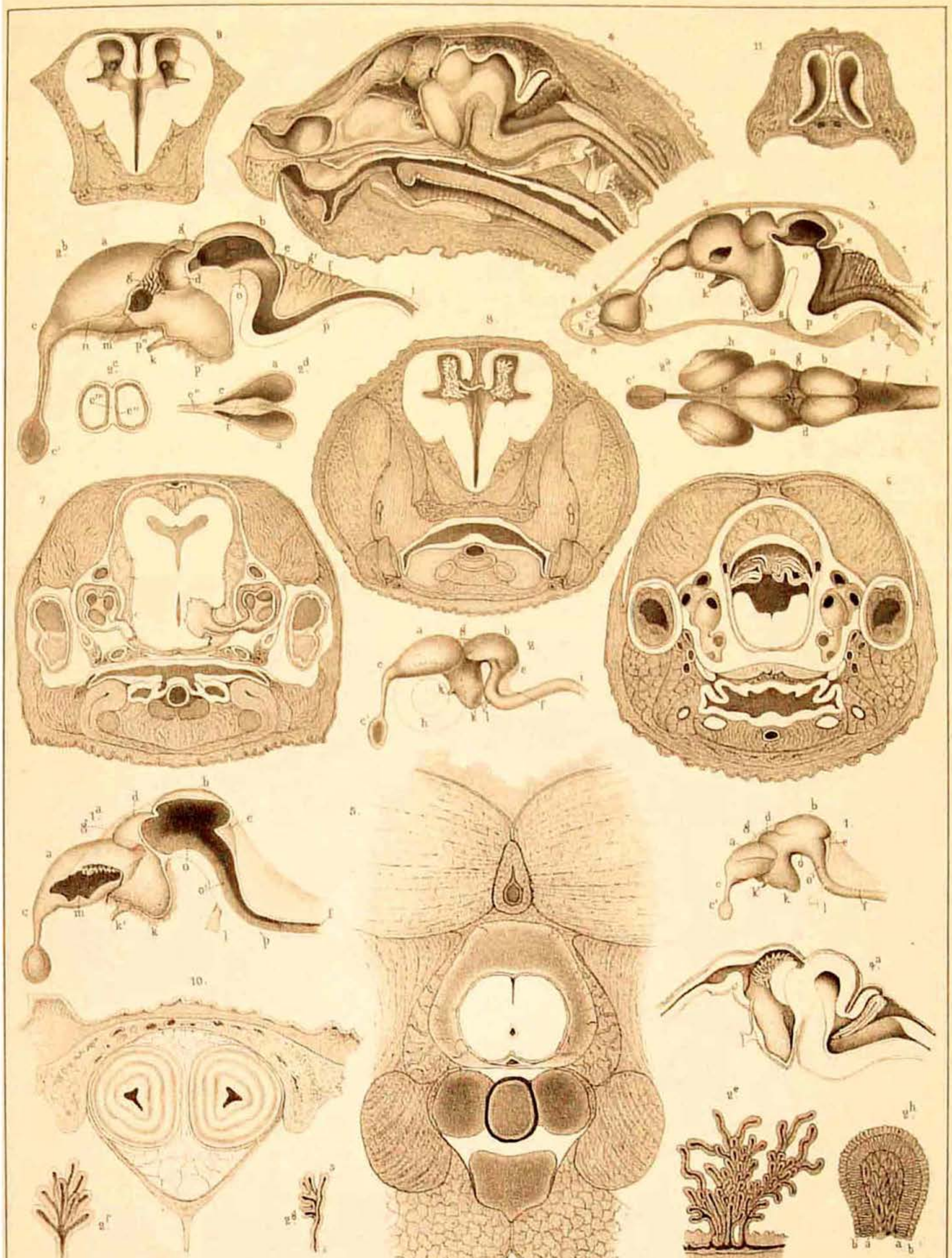
Clark Gunn del. Sonrel on stone. L. H. Bradford & Co. print.

HISTOLOGY.



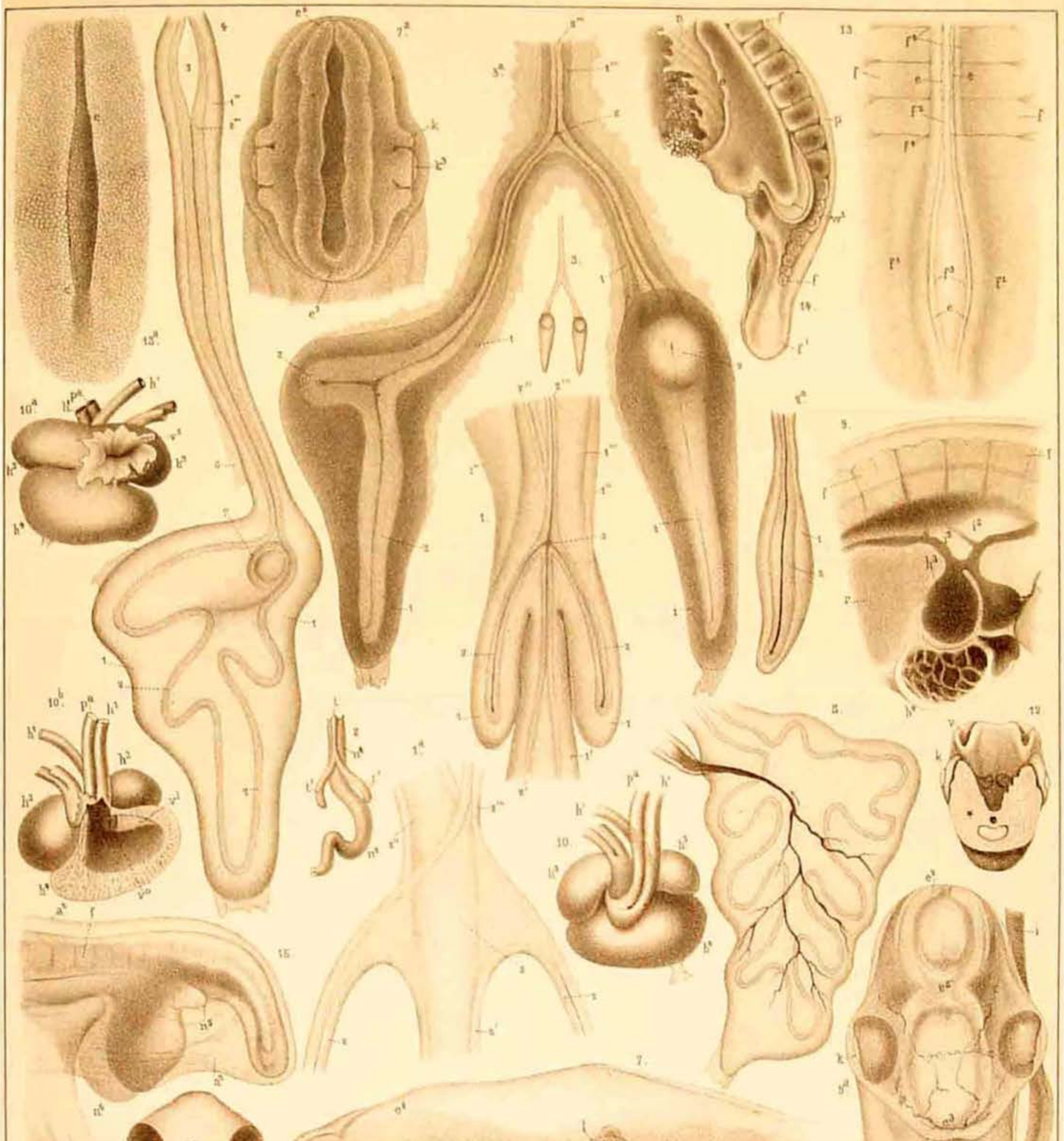
Clark from nat. Ibbotson on stone J. H. Bradford & Co. print.

HISTOLOGY.



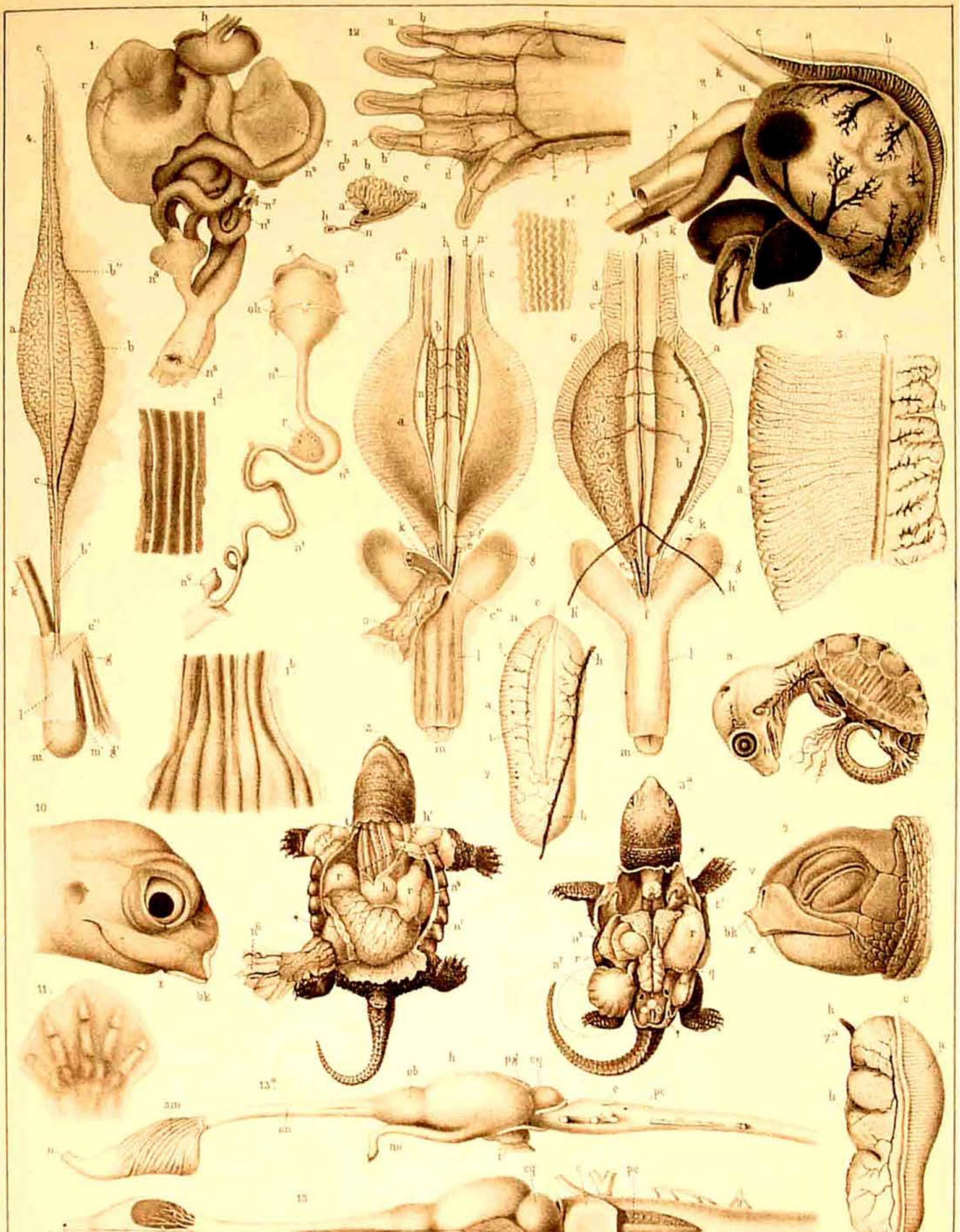
Clark from nat. Ibbotson on stone L. H. Bradford & Co. print

DEVELOPMENT OF THE BRAIN



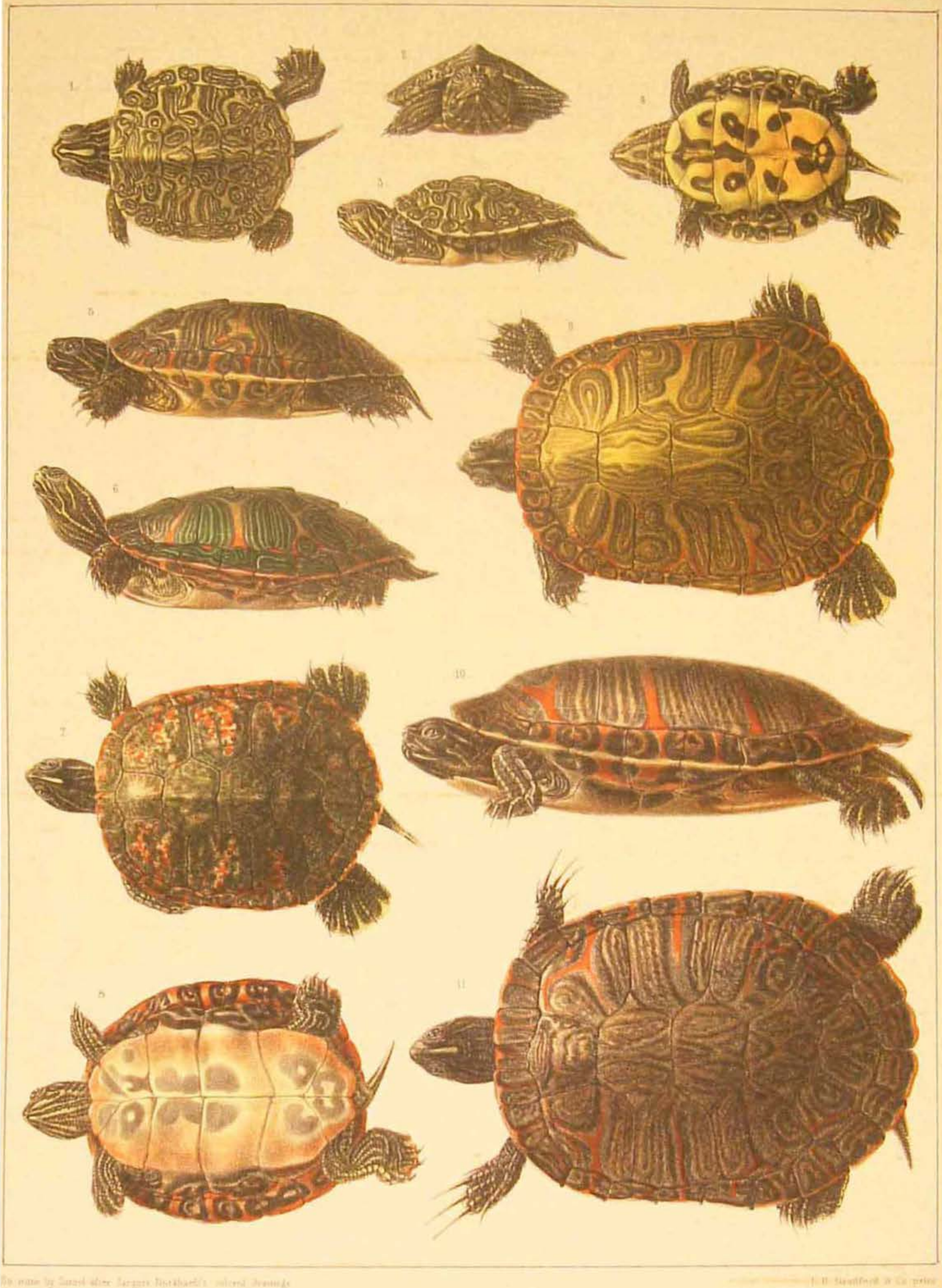
H. J. Clark from nat. Ibbotson on stone. L. H. Bradford & Co print.

FORMATION OF ORGANS.



Clark & Sonrel from nat. [illegible] on stone   L. H. Bradford & Co print.

FORMATION OF ORGANS



On stone by Sonrel after Jacques Burkhardt's colored drawings. J. H. Bufford & Co. print.