CONTRIBUTIONS

TO

THE NATURAL HISTORY

OF THE

UNITED STATES OF AMERICA.

BY

LOUIS AGASSIZ.

SECOND MONOGRAPH.

IN FIVE PARTS.—I. ACALEPHS IN GENERAL.—II. CTENOPHORÆ.—III. DISCOPHORÆ.—IV. HYDROIDÆ.
—V. HOMOLOGIES OF THE RADIATA; WITH FORTY-SIX PLATES.

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PREFACE.

While most readers seeking comprehensive information may have had their attention drawn to the generalizations contained in the first part of this work, the naturalists who have studied the second and third parts may have noticed that the subjects under consideration there are treated in a different manner from that generally adopted in similar investigations. Confident that what have been called *our* classifications are in reality the various readings of a system which truly exists *in nature*, I have endeavored to show, that, in arranging their systems, zoölogists have unconsciously followed great natural relations in the animal kingdom, and that what they have supposed to be their invention was only their instinctive perception of an order which unites under a consistent plan all the isolated facts studied by them. My first step in the attempt to demonstrate this proposition was to collect all the facts relating to our science and to compare them carefully with the systems, testing the one by the other. By the coincidence of the two I hope to have proved that the Power which originated the facts must also have originated the ideas expressed in the systems; and that the latter are true only so far as they adhere to the great system of Nature from which they have been transcribed. The first monograph, limited to a single Order, afforded, however, a meagre field for such a demonstration; though it was broad enough to allow of the attempt without modifying too much the usual mode of treatment of such subjects. But finding, after many years' application of that method in my own investigations, that, far from complicating my studies, I only derived daily additional facilities in tracing the manifold relations which unite all kinds of natural groups among animals, I have resolved upon combining, through the presentation of a whole Class, the description of the facts, with a critical analysis of their meaning, as far as they have a bearing upon classification. How successful the attempt has been, time will show.

In selecting the class of Acalephs for such an experiment on a larger scale, I was influenced by the circumstance that these animals had attracted my special attention for many years past; and that, being particularly familiar with them, it was easy for me to treat them as known quantities. Besides this, they afforded in themselves a rich field for extensive comparisons with numerous other classes, with which some of their number had been associated at different times. And again, their remarkable modes of development could not fail to bring to a test the value of the changes which they undergo during their growth for the purpose of ascertaining the affinities and relative rank of animals. The circumstance that the study of this class has received less attention in America than any other, had also much weight with me, as it gives me an opportunity of making our students more intimately acquainted with those naturalists, who, in Europe, have given a new aspect to Zoölogy since the days of Cuvier, and who, not being ornithologists, entomologists, or conchologists, are hardly known here as they should be; for it is much to be regretted, that, with the Anglo-Saxons, Zoölogy has now become too much a descriptive or too much a speculative science.

To the general reader the first part of this volume may be of some interest, inasmuch as it presents a general account of the progress of Zoölogy since the time of Aristotle to the present day with special reference to the class of Acalephs, including, besides, such generalizations as may be deduced from a comparison of these animals with the representatives of other classes. To the professional naturalist I venture to recommend the second part as containing additional information respecting the structure of the Ctenophoræ not to be found in previous contributions to their natural history, and I ask especial attention to the discussions in which the value of the natural groups admitted in that Order is considered in detail.

In the preparation of this part of my work I have received much valuable assistance from my friend and colleague, Professor H. J. Clark, who has traced with me, for more than nine years, the metamorphoses of our Acalephs, and especially those of the Hydroids; besides which he has investigated for himself some special points of their structure, which are noticed as his contributions in the proper place: but I would particularly call attention to the description of the lasso-cells of the Ctenophoræ on page 237, and to the investigation of the structure of the eye of our Aurelia, which will be published in the next volume, and the illustrations of which, drawn by him, Pls. XI[b]., and XI[c]., are issued with this volume.

Most of the plates were drawn from nature and on stone by Mr. Sonrel; and it is but justice to him to say, that I do not know representations of Acalephs executed with greater accuracy, patience, and skill. Only those fully conversant with the whole range of our literature on this subject can do complete justice to their great merit; and I can truly say, that, without the aid of his persevering zeal, I could not have accomplished what I aimed at in this volume.

I have, further, derived much assistance in my work from the liberality of the Smithsonian Institution, in lending me books not to be found in the libraries of Boston and

Cambridge. The collection of scientific periodicals of the Smithsonian Institution is unquestionably the largest on this continent, and but for the wise policy of Prof. Henry, the enlightened head of that establishment, the naturalists of America could not at this time make any investigations involving historical researches. Next to the Smithsonian Institution I have to mention the Academy of Natural Sciences in Philadelphia, the library of which has acquired the highest importance for naturalists, through the liberality with which Dr. Wilson has supplied its wants.

The Museum of Comparative Zoölogy in Cambridge contains specimens of all the Acalephs described in this work which could be preserved. And I would take this opportunity to say, that, with proper care, a much larger number of these animals may be preserved in a state fit for study than is generally supposed. Valuable specimens were sent to me by Professor J. Leidy, collected by him in Long Island Sound and along the shores of the Middle States, some of which he has himself described in his contributions to the Marine Faunæ of Rhode Island and New Jersey. Others, from the same localities, were presented to me by Mr. Samuel Powel of Philadelphia, among which I would especially mention the Cordylophora described by Prof. Leidy. To my friend Theodore Lyman I am indebted for fine specimens of several Hydroids of the Bay of Boston, and to Mr. William Stimpson for others from the eastern shores of the Northern States. To my friend T. G. Cary, and to my son Alexander Agassiz, who have enriched the Museum of Cambridge with immense collections from California, I owe many specimens of Acalephs from the west coast of North America. Captain W. H. A. Putnam, of Salem, to whom our Museum is indebted for the most valuable collections from the Indian and Pacific Oceans, has brought me a number of Medusæ and Hydroids from the East Indies and from the Gulf Stream, which, after years, are still in a good state of preservation. To Mr. John McCrady I am indebted for an early communication of his contributions to the history of the Acalephs of South Carolina. I would add also, that in the Aquarial Gardens of Boston I have frequently had opportunities of observing many of our Hydroids and Medusæ in a fine state of preservation.

It is but proper, that, in leaving this volume to speak for itself, I should also mention the facilities constantly afforded me by the publishers for making it as worthy as possible of the extensive patronage it has received.

LOUIS AGASSIZ.

CAMBRIDGE, October 31, 1860.

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NORTH AMERICAN CTENOPHORÆ.

PART I.

ACALEPHS IN GENERAL.

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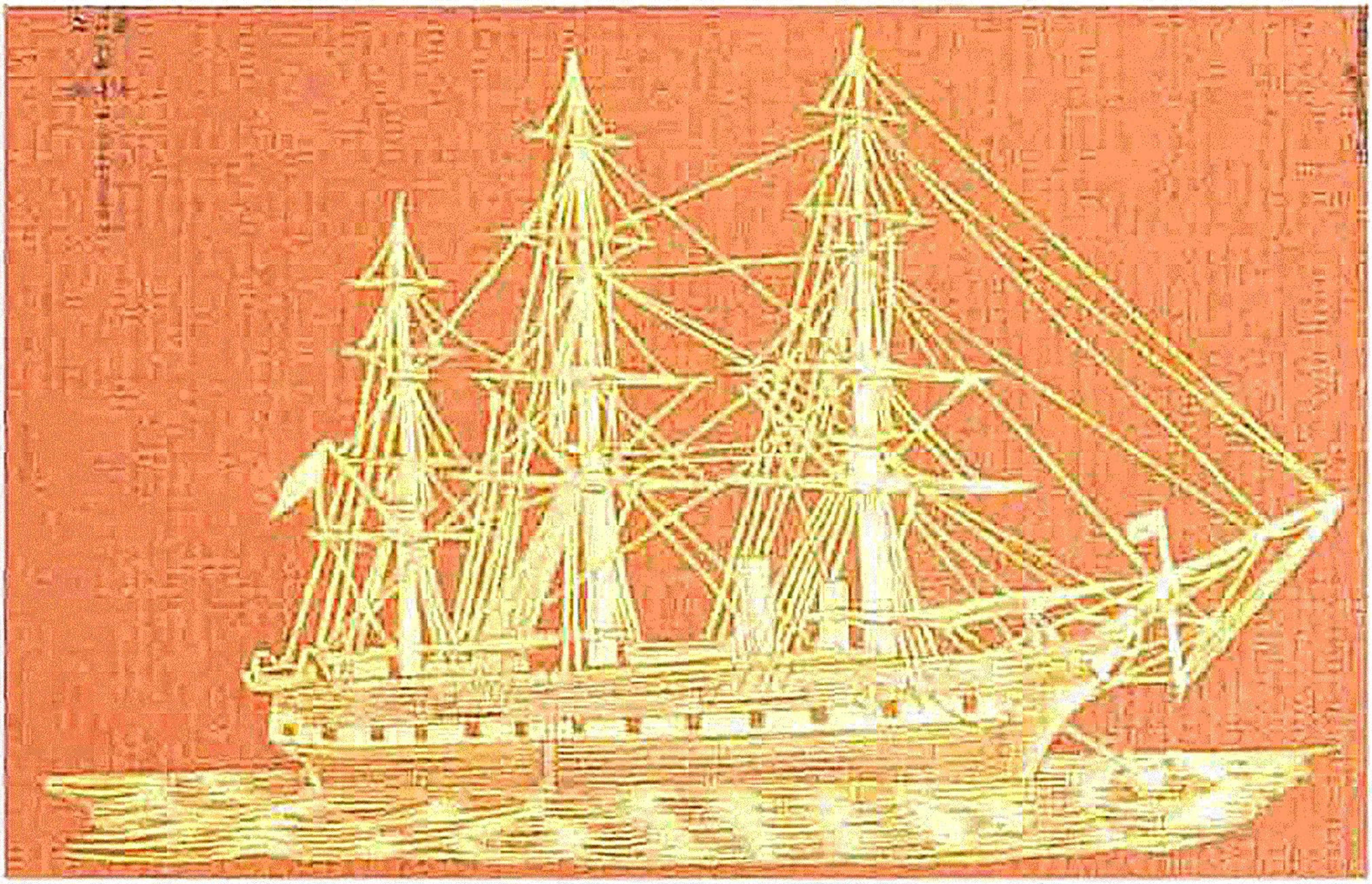


H.M.S. CHALLENGER

ACALEPHS IN GENERAL.

CHAPTER FIRST.

HISTORY OF OUR KNOWLEDGE OF THE ACALEPHS.

SECTION I.

PERIOD OF ARISTOTLE AND THE ROMAN NATURALISTS.

It is one of the most instructive studies to trace the efforts of the human mind in its successive attempts to understand the phenomena of Nature. This study is particularly attractive when it is pursued in connection with a subject which has taxed the ingenuity of man for a long series of ages; and it may well be said, that, except Astronomy, no other field affords so much material for such investigations as Zoölogy, on account of the early attention paid by philosophers to the study of animated beings. From Aristotle to this day we have an uninterrupted series of writers who have recorded their views of the nature of animals, and thus enable us to ascertain what successive steps have been made towards a more extensive acquaintance with, and a more accurate appreciation of, the nature, the affinities, the structure, and the mode of development, of the whole animal kingdom. And while thus following up the long record of the progress of human knowledge in this direction, an attentive observer cannot fail to be struck with the similarity noticeable between the earlier views presented by the older writers on these topics, and the impression he himself is likely to have received when contemplating for the first time the same objects. Not less striking is the coincidence between the sum total of the information gradually obtained in course of time, and the successive steps made by those who have approached these studies without a previous acquaintance with the labors of their predecessors. The study of the Acalephs, under which name naturalists now include the so-called jelly-fishes or sea-blubbers or sun-fishes, and the animals allied to them, affords a striking example of this correspondence between the gradual progress every one must make who attempts to understand their nature, and the successive stages of the science relating to these animals as recorded in the works of the authors of past ages. When we first observe a jelly-fish, it appears like a moving fleshy mass, seemingly destitute of organization; next, we may observe its motions, contracting and expanding, while it floats near the surface of the water. Upon touching it, we may feel the burning sensation it produces upon the naked hand, and perhaps perceive also that it has a central opening, a sort of mouth, through which it introduces its food into the interior. Again, we cannot but be struck with their slight consistency, and the rapidity with which they melt away when taken out of the water. But it is not until our methods of investigation are improved; and when, after repeated failures, we have learned how to handle and treat them, that we begin to perceive how remarkable and complicated their internal structure is; — it is not until we have become acquainted with a large number of their different kinds, that we perceive how greatly diversified they are; — it is not until we have had an opportunity of tracing their development, that we perceive how wide the range of their class really is; — it is not until we have extended our comparisons to almost every type of the animal kingdom, that we can be prepared to determine their general affinity, the natural limits of the type to which they belong, the distinctive characteristics of their class, the gradation of their orders, and the peculiarities that may distinguish their families, their genera, and their species. We cannot, therefore, expect to find, in the older writers upon Zoölogy, any thing like a natural classification of these animals. Even Aristotle, whose keen mind has thrown so much light at such an early period upon the natural affinities of the higher animals, has failed entirely to recognize the relations which exist between them and the star-fishes and sea-urchins. All that he, and other naturalists, up to a very recent period, tell us about them, amounts to little more than the first impression they make on those who see them for the first time, without attempting to compare them with other animals.

For this reason I have thought it desirable to introduce a brief account of all that has been written upon the subject of Acalephs, as far as the condition of the libraries in this part of the world will permit it, not only with a view of thus recapitulating the successive stages of our knowledge of these beings, and comparing them with our daily experience in attempting to unravel all the mysteries connected with their history, but also with a hope of accounting for the very questionable terminology used at present by all naturalists in describing the parts of these singular beings.

The earliest accounts extant, relating to Acalephs, are contained in a few passages of the History of Animals by Aristotle; but these are very meagre, and show that the great Greek philosopher had no very clear idea either of their affinities or of their structure.[1] He speaks of them under three names; calling them, in some of his passages, Acalephæ, in others, Knidæ, and in another, Pneumones. A careful comparison of all the passages in which these animals are mentioned, shows that the names of Acalephæ and Knidæ were probably applied to Actiniæ and to Medusæ indiscriminately, and that Aristotle himself did not distinguish these animals accurately, or, at least, did not know in what their essential differences consist, for, speaking of Acalephæ as well as of Knidæ, he only says that there are two kinds, one of which is attached to the rocks, while the other may free itself and seek its food by night; which seems to indicate that he believed the free Medusæ to be at times attached like the Actiniæ, and capable of freeing themselves at will, or that the Actiniæ, freeing themselves, become Medusæ.[2] Taking into consideration, however,

[1] The best edition of the Zoölogical works of Aristotle is that of Io. GOTTLOB SCHNEIDER; Aristotelis de Animalibus Historiæ, Lib. X., Græce and Latine, Lipsiæ, 1811, 4 vols. 8vo. The best translation is that of DR. FR. STRACK into German: Aristoteles Naturgeschichte der Thiere übesetzt und mit Anmerkungen begleitet, Frankfurt am Main, 1816, 1 vol. 8vo. The French translation by Camus, Paris, 1783, 2 vols. 4to., is less accurate. There is no good English translation.

[2] As the account which LESSON gives of the views of Aristotle relating to Medusæ, in his *Histoire Naturelle des Zoöphytes: Acalèphes*, Paris, 1843, is far from accurate, I deem it necessary to introduce here a literal translation of all the passages of the original text relating to that subject.

The name *Acalephe* appears in six different passages in Aristotle. First, in Book I. Chap. I. Sec. 6, when, speaking of the habits and functions of animals, he says, that "there are some which get their food in the water, and are unable to live out of it; they do not, however, take in either air or water, as the Acalephe and the Ostrea." Next, in Sec. 8, speaking of the ability of animals to change their place, he says, "some both attach and detach themselves, as a genus of the so-called Acalephæ, for some of these, detaching themselves by night, go about to feed." In Book IV. Chap. VI. Sec. 4 and 5, when speaking of the structure of the marine animals, he mentions that "there is also the genus of the Acalephæ, which is peculiar; they cling to the rocks, like some of the shell fishes, but occasionally free themselves. They have no shell, but their whole body is fleshy, and they feel, and seize the hand approaching them, and then hold it, as the Polypus" (which is the Octapus of modern systematic writers) "does with its feelers, in such a manner as to cause the flesh to swell. They have the mouth in the middle, and live from the rocks as from a shell" (which probably means that the rocks afford them the same protection as the shell gives to the oyster). "If any one of the small fishes falls in their way, they hold to it, as to the hand; so also if any thing eatable falls in their way, they devour it, and one genus frees itself and feeds upon scallops and sea-urchins, whenever any thing falls in its way. They seem to have no visible exrements, but in this they resemble the plants. There are two genera of Acalephæ, one of which is smaller and more eatable, the other large and hard, like those found about Chalcis. During the winter their flesh is firm, wherefore they are caught, and are eatable; during summer they perish, for they become soft, and, if touched, are easily torn, and cannot be taken off at all that is said about Acalephæ and Knidæ, it would seem as if the name of Knidæ applied more particularly to Medusæ, as these are the only ones of which he seems to have known that they possessed burning properties, the nature of which could not have been very clearly understood by him, for he says, when speaking of the Sea Scolopendra (probably some Nereis), that it does not bite with the mouth, but produces with the whole body a painful sensation like that caused by the Knide. The description he gives of the Acalephæ applies particularly well to the Actiniæ, and but for the statement that they free themselves could not be applied to any Medusa. Of the Pneumon, he only states, that they are formed out of themselves.

Neither Pliny[1] nor Aelian nor Oppian nor Galenus, nor the writers of the middle

all; and, suffering from the heat, they retire further among the rocks." In Book VIII. Chap. I. Sec. 3, when, speaking of the intensity of life and its gradations, he considers the marine shells and the Ascidians as intermediate between the higher animals and plants. "The transition from them to the animals is uninterrupted, as has been said before; as to some of those in the sea, one might doubt whether they are animals or plants, for they are attached, and many of them, when separated, are destroyed. In some, the nature of the body is fleshy, as in the so-called Tethya (our Ascidians) and the genus of the Acalephæ. The sponge, however," he adds, "is entirely like the plants"; and in Chap. III. Sec. 3, he says that "the Acalephæ live upon whatever small fishes fall in their way, and that they have the mouth in the middle, which is most evident in the largest ones. They have also, like the oyster, an opening where the food passes out, and this is upward. In a general way the Acalephæ resemble the internal fleshy part of the oyster, and it uses the rock as a shell."

The name Knide occurs twice. First, in Book V. Chap. XIV. Sec. 1, where it says that "the Knidæ and the Sponges, which are found in the clefts of the rocks, though without a shell, multiply in the same way as the shell fishes. There are, however, two genera of Knidæ: one in the hollows, which never frees itself from the rocks; and another, living upon flat, smooth bottom, which detaches itself and moves from place to place." And in Book IX. Chap. XXV. Sec. 4, when speaking of the sea-snakes, he says of the Sea Scolopendra (our Nereis), that "when it has swallowed the hook, it turns itself inside out until it expels the hook, and then turns itself back again; it does not bite with the mouth, but its whole body produces a painful sensation, like that of the Knidæ."

The name Pneumon occurs but once (Book V. Chap. XIII. Sec. 10), when, speaking of the reproduction and growth of animals, he only says that the so-called Pneumon "is formed from itself," meaning that it is spontaneously generated. From this passage it could hardly be inferred that Aristotle designated an Acalephe under the name of Pneumon. But when we consider how the Grecian colonies were scattered along the shores of the Mediterranean, and that the name Pulmo Marinus was early applied to the large Rhizostoma of the Mediterranean, and even figured under that name by Mathioli; that the Rhizostoma may aptly be compared to a floating lung; and further, that this largest Medusa of the Mediterranean is commonly called Poumon de Mer by the French fishermen, — the conclusion is irresistible, that, if the Latin and French names are not a translation of the Greek "Pneumon," this name is likely to have been given to that large Medusa for the same reason for which the French call it sea-lung. It is singular, however, that Rondelet, who first represented the Rhizostoma, should have failed to recognize it as the Pneumon of the Greeks, and applied the name to a compound Ascidian.

[1] The best edition of the Natural History of Pliny is that published in Paris in 1828 by Lemaire, under the supervision of Ajasson de Grandsagne:

ages,[1] added any important information to that already contained in Aristotle; and we must come down to the sixteenth century, before we find authors who have observed Medusæ in nature, and given rude outlines of their external appearance. Among them Bélon and Rondelet deserve particular mention, for they were the first who published wood-cuts representing several species of Actiniæ and Acalephæ; and, though their knowledge of these animals is not more accurate than that of Aristotle, a new era in the natural history of animals begins with them and Gessner.

SECTION II.

THE NATURALISTS OF THE SIXTEENTH AND SEVENTEENTH CENTURIES.

The connection between the extraordinary impulse which the natural sciences received in the second half of the sixteenth century, and the preceding momentous

Caii Plini secundi Historiæ Naturalis libri xxxvii. The third part, devoted to Zoölogy, contains notes and dissertations by G. Cuvier.

Most of what is contained in Pliny respecting the Acalephs (Lib. ix. cap. 45) is compiled from Aristotle, though it appears from his description, that he must have observed these animals himself, as he mentions the manner in which they move about, and seize their prey. As the name Zoöphytes has been applied to the lower animals by most writers on natural history since Pliny, it is not out of place to mention here, that that word was first used by Sextus Empiricus, and no doubt suggested by a passage of Aristotle quoted above (note on p. 6), in which the gradation from the higher animals to the plants is alluded to. But, far from constituting a progress in science, that designation introduced only confusion, or at least served to propagate a false impression that there were living beings truly partaking at the same time of the nature of animals and plants. Nothing can be further from the truth than to ascribe such a view to Aristotle as his commentators Gaza and Budæus have done; for, though Aristotle alludes to a gradation among animals, and to a sort of transition from them to the plants, which he considers as inanimate, he nowhere regards those animals which are immovable, like plants, as ambiguous in their character, but everywhere speaks of them as living animals, and alludes to the Sponges as plants. These erroneous notions have been entertained for nearly two thousand years, until Peyssonel demonstrated the animal nature of the expanded individuals of these so-called Zoöphytes, in which some of his predecessors had fancied they saw real flowers.

[1] The readers who may wish for more information respecting the progress of science during this and the following periods, in which the natural history of the Acalephs made comparatively less advance than that of other classes, are referred to G. CUVIER, Histoire des sciences naturelles depuis leur origine jusqu'à nos jours, Paris, 1841–1845, 5 vols. 8vo., and Histoire des progrès des sciences naturelles depuis 1789 jusqu'à nos jours, Paris, 1829, 4 vols. 8vo. — DEBLAINVILLE, Histoire des sciences de l'organisation et de leurs progrès, Paris, 1847, 3 vols. 8vo. — Also, SPIX Geschichte und Beurtheilung aller Systeme in der Zoologie nach ihrer Entwickelungsfolge von Aristoteles bis auf die gegenwärtige Zeit. Nüremberg, 1811, 1 vol. 8vo., and for the middle ages in particular: POUCHET, Histoire des sciences naturelles au moyen age, Paris, 1853, 1 vol. 8vo.

historical events, is not difficult to trace. The establishment of the Mahometans in Spain, and, some centuries later, the Crusades, had brought the West into direct contact with the East, where the Arabs had kept alive the traditions of Greek learning, and the foundation of the great universities of Europe in the twelfth and thirteenth centuries was the result of the intellectual impulse which this intercourse aroused. The institution of the mendicant orders, which were established at the same time, and whose office was chiefly to teach, stimulated this activity still further; while the overthrow of the Byzantine Empire, in the middle of the fifteenth century, sent westward many of the most learned Greeks of that age. Then came the Reformation, with its all-embracing discussions upon the most important problems of mental activity, — the introduction of the arts of printing and engraving, multiplying a thousand-fold the influence of thought, — the invention of gunpowder and of fire-arms, bringing brute force under the control of intellectual energy and foresight, — the discovery of America, and of a passage into the Pacific Ocean around the Cape of Good Hope and the southern extremity of America, opening new worlds to the investigations of the learned.

The extraordinary activity then prevailing manifested itself in the most striking manner also among those whose inclination tended towards the study of nature, and of man as an intellectual being. Besides philosophy and mathematics, we see human anatomy taught in the public schools, and extending its influence over the investigations of the whole animal kingdom; so that the great anatomists of the sixteenth century, Vesalius, Fallopius, Eustachius, Fabricius ab Aquapendente, and Harvey, had their peers among the naturalists in Wotton, Bélon, Salviani, Rondelet, Gessner, Aldrovandi, and Fabio Colonna. Among these, we are chiefly indebted to Rondelet for contributions to the natural history of the Acalephs. He was, indeed, not only better acquainted with the inhabitants of the Mediterranean than all his predecessors, but he knew them even more accurately than any naturalist that lived before the present century. Professor of Anatomy in the University of Montpelier, where he had the best opportunity for studying the marine animals of the Mediterranean, he has published a work upon the fishes inhabiting that sea, which challenges our admiration even now;[1] and if his account of the soft-bodied animals is far inferior to his descriptions of the other types of the animal kingdom, it is simply to be ascribed to the mode of investigating which has too long prevailed, and from which even some of the living naturalists are not yet altogether free, — that of removing the animals to be examined from their natural element in order to describe them. While there is hardly a naturalist at present who does not know

[1] GUIL. RONDELETII libri de piscibus marinis, Lugduni, 1554, 1 vol. fol. The 14th Chap. of the 17th book is devoted to the Acalephs, which he calls *Urticæ* (nettles).

that neither Polyps nor Acalephs nor Mollusks will exhibit their natural appearance when taken out of the element in which they live, it is still to be lamented that both the star-fishes and sea-urchins are everywhere represented as they appear when taken out of the water, and all their soft appendages, so numerous and diversified, are drawn in or so contracted and collapsed as no longer to give the slightest idea of their natural beauty.[1] Like Aristotle, Rondelet still unites the Actiniæ and Acalephæ under the name of sea-nettles (Urticæ marinæ), distinguishing the former as the fixed sea-nettles and the latter as the free sea-nettles. Even Cuvier, in his earlier works, allows these animals to remain together, though it was he himself who separated them afterwards, for the first time, as members of two distinct classes. Rude as are the illustrations published by Rondelet, it is hardly possible to mistake in his fifth species the Rhizostoma of Cuvier, although the disk is too small and the arms too straight, and in the sixth the Chrysaora of Péron, although Linnæus refers that figure to the Aurelia aurita.

In the writings of Aristotle a single part of the Acalephæ is distinguished by name, — the *mouth*, which occupies the centre of the body, of which nothing is stated except that it is fleshy. The passage already quoted from Pliny (Lib. IX. ch. 45) speaks of *leaves* ("ac prænatante pisciculo *frondem* suam spargit"), no doubt meaning by *frons* the thin, expanded margin of the disk, and the appendages about the mouth, which he considers as a *root* ("ora ei in radice esse traduntur"), thus carrying out a comparison of these beings with plants. Rondelet, on the contrary, vindicates especially their animal nature when he says, that since they alternately expand and contract their blade, which serves as feet, and since they absorb food through the mouth and thus show themselves provided with the senses of touch and taste, which are essential to the animal life, he considers them as imperfect animals, and not as Zoöphytes, as Pliny does.[2] Speaking of the small sea-nettle, which is his first species, he mentions its short tentacles, and its resemblance to the large intestine, thus distinctly pointing to the genus Actinia, of which, he says, there are several varieties, some green, some blue, some blackish, with blue, yellow, or red spots. His second species seems to be a Tubulibranchiate Annelid, for he says it bites. His third species is another Actinia, with which he confounds the Æquorea of the Mediterranean.[3]

[1] In my next Monograph I shall have an opportunity of representing the North American Echinoderms as they appear in life.

[2] Cum igitur Urticæ frondem suam, quæ pedum vice est, modò dilatent modò contrahant, cum ore cibum accipiant, id est, cum tactu gustuque, qui duo sensus ad vitam animalium sunt necessarii, præditæ sint, non inter Zoophyta, ut Plinius, sed inter animalia non omnino perfecta, eas numerabimus. Rondeletius. Lib. XVII. p. 527.

[3] It can hardly excite surprise to find, that, with as little knowledge as Rondelet possessed upon the subject of Acalephs in general, he should have confounded a Medusa and an Actinia, especially when it is remembered that the numerous radiating tubes of the Æquorea give it a greater resemblance to an

The fourth species is unmistakably the Actinia senilis. Speaking of the fifth species, which is the Rhizostoma, he compares the disk to a hat, and the eight pendant appendages to the feet of the Octopus. Of the sixth species, he says that the four feet may be compared to Acanthus leaves.[1]

Gessner, in his great Natural History of the Animals, has followed Rondelet for the Acalephæ, as he did for most of the other productions of the Mediterranean; and also copied his figures and those of Bélon, adding only such remarks as exhibit his vast erudition, but in no way a better acquaintance with the animals themselves.[2]

It has been a source of constant delight for me, while perusing the works of the earlier naturalists, to sympathize with the genial spirit and the earnestness that pervade their writings, so free from egotism, and animosity against their fellow-students. Their devotion to their studies is equal to the spirit of reverence with which they look upon nature; and it is disgraceful to our age, that we must contrast with such dispositions the ill-will, the jealousies, the quarrels for priority, and the profanation, which pervade the discussions of certain modern authors. Moreover, in a systematic point of view, the great naturalists of the sixteenth century deserve to be studied more fully than they have been thus far. It is astonishing, for instance, to see how near Rondelet, in discussing the views of Aristotle upon the affinities of animals, came to perceiving their true affinities, and their natural classification under four great types. In the 1st Chapter of the 17th Book of his great work, "*De Piscibus Marinis,*" after describing the fishes of the Mediterranean, he says, that having thus described the *Enaima,*— that is, the animals provided with blood,— he now proceeds to describe the *Anaima,* among which he distinguishes the *Malakia* in contradistinction to the *Sklero-derma.* These Malakia are the Cephalopoda, to which unfortunately the Medusæ are added on account of the appendages around the mouth, which were compared by him to the feelers of the cuttle-fish. In Book 18th he treats of the Crustacea under the name of *Malakostraca,* and distinguishes from them the *Ostrakoderma,* or shell fishes,

Actinia than any other Medusa has; but that he did confound the two is plain from the following words: "Saxis aliquando hæret, aliquando soluta vagatur." The purple color of the Æquorea may also have contributed to mislead him.

[1] Here, then, we have for the first time the word *pileus* (hat) introduced to designate the disk of the Medusæ, an expression that has been retained by most later writers, while some zoölogists have substituted for it the name of *umbrella,* or *disk;* while the word *feet* stands for the appendages around the mouth, to which the name *arms* was afterwards more generally applied.

[2] An interesting notice of the life and writings of Gessner, by Cuvier, may be found in the Biographie universelle, vol. 17, and in the Histoire des sciences naturelles, vol. 2, p. 83. I would gladly also refer to the notice by Blainville in his Histoire des sciences de l'organisation; but that chapter is so interwoven with jesuitical insinuations as to be utterly unpalatable to a sober thinker. The chapter on Acalephæ in the Historia animalium of Gessner is contained in Book 4, De piscium et Aquatilium animantium natura, page 1239, published in Zürich in 1558.— Bélon's book, de Aquatilibus, Lib. II., was printed in Paris in 1553.

associating erroneously, however, the sea-urchins with the former. But again, in the second part of his work, which appeared one year later than the first, discussing the characteristics of the *Ostrakoderma*, or Conchifera, and comparing them to the *Entoma*, or Insects, he unites the bivalve and univalve shells into one great division. In this arrangement, Rondelet is already as far advanced as Lamarck, who separates the Cephalopoda as a distinct class from the Conchifera. With reference to the *Entoma*, or Insects, which he characterizes as animals having incisions above or below or on both sides and no bony parts, he unites the Worms and the Annelids with a small Crustacean, and associates also the Star-fishes and Holothuriæ with them, a combination which even Oken has thought natural.

Among the other naturalists of the sixteenth and those of the seventeenth century, there are a few more who deserve to be mentioned as contributors to the natural history of the Acalephs. Matthioli, for instance, while commenting upon the plants of Dioscorides,[1] introduces some remarks upon Acalephs and other Zoöphytes of which he gives wood-cuts. In part second of the same work, published in 1555, there is a figure of a Beroid Medusa, in a short paragraph "De Cucumere marino," p. 131; and another of the "Eschara," p. 133. Wotton, also,[2] speaking of Zoöphytes, mentions the sea-lungs and sea-nettles; and, somewhat later, Aldrovandi,[3] in his gigantic Cyclopedia of Natural History, published in fourteen large volumes, folio, partly by himself and partly from his papers after his death, mentions also some of these animals, without, however, adding any thing that would throw new light upon their nature. The same may be said of the work of Jonston.[4] It would lead me too far were I to attempt here to give ever so short an account of the rather indifferent notices relating to Acalephs that are scattered in the writings of the other naturalists of this period. It may suffice to quote their works, and refer the reader to the originals.[5] One remark, however, applies to most of them, and characterizes the spirit

[1] MATTHIOLI (P. A.), Commentarii in sex libros Dioscoridis de medica materia; adjectis magnis ac novis Plantarum ac Animalium iconibus, etc., Venetiis, 1554, fol. fig. — Compare also CÆSALPINUS (A.), De plantis Libri XVI. Florentiis, 1583, 4to.

[2] WOTTON (EDW.), De differentiis Animalium, Libri X. Parisiis, 1552, fol.

[3] ALDROVANDI (UL.), Historia Naturalis, Bononiæ, 1599–1640, 14 vols. fol. fig.

[4] JONSTON (J.), Historiæ Naturalis de Exanguibus aquaticis Libri IV. Francofurti ad Moenum, 1650, fol. fig. — Book IV. p. 72 is devoted to the Zoöphytes in general, among which he includes, with Rondelet, the Actiniæ and Medusæ, the Holothuriæ, the Ascidiæ, and the Halcyonoid Polyps. His figures are copied from Bélon, from Rondelet, from Aldrovandi, and from Matthioli.

[5] SALVIANI (HIPP.), Aquatilium animalium Historia, Romæ, 1554, fol. fig. — IMPERATO (FERR.), Historia naturale, nella quale si tratta della diversa condizione de Minere, Pietre preziose e altre curiosità, con varie istorie di Plante e Animali, Napoli, 1559, fol. — CLUSIUS (CAR.), Exoticorum libri decem, quibus Animalium, Plantarum aromatum aliorumque peregrinorum fructuum historia describuntur, Anvers, 1605, fol. fig. — COLONNA (FAB.), Aquatilium et terrestrium aliquot animalium aliarumque naturalium rerum observationes, Romæ,

of the age. They are full of discussions upon the animals known to the ancients, mixed up with a few original observations, showing plainly the influence exercised by the revival of letters even upon the cultivators of science.

The naturalists of the second half of the seventeenth century gradually turn their attention more exclusively to nature, and are less engrossed by mere questions of erudition. This salutary change is no doubt owing to the influence of the discovery of America, and the progress of navigation around the Cape of Good Hope and in Asia, upon the study of Natural History. The animals and plants brought back to Europe by travellers, and still more the observations published by physicians and naturalists who explored the new world, must early have impressed on every one the conviction, that the productions of these countries could not be illustrated by references to the writers of past ages. No expedition contributed more powerfully to strengthen this impression, and to extend the range of human knowledge respecting the animals and plants of foreign lands, than that of Count Maurice of Nassau to the Brazils. The work of Marcgrave,[1] who was naturalist to that expedition, remained until the beginning of this century the principal source of information respecting the animals of South America; but it contains nothing relating to Acalephs. Dutertre[2] and Martens[3] have only a few remarks about them, while Boccone's[4] investigations relate chiefly to the Corals. At home, both naturalists and zoölogists, as well as philosophers generally, apply themselves with increased zeal to the investigation of minute objects and abstruse questions requiring improved methods of study; and, of course, the advance made in one branch leads to new researches in other branches, so that it may well be said, that there never was a time when the aspirations of men for knowledge were higher and more intense than during this period. This intellectual movement naturally gave birth to the scientific academies founded with a special view to the promotion of experimental researches. The principal of these academies were, that of the Lyncei in Rome, the Philosophical Society in London, the Academia Naturæ Curiosorum in Germany, and the Académie des Sciences in Paris.

1616, 4to. — SCILLA (AGOST.), La vana speculatione desingarata del senso, Napoli, 1670, 4to. fig. Though many of the works quoted are insignificant for the study of Acalephs, their value is very great in other respects. Scilla, for instance, opens that series of investigations upon fossil remains which has made Palæontology a distinct science. The works of Clusius, Matthioli, and Cæsalpinus, are essentially botanical, and that of Salviani is entirely ichthyological.

[1] MARCGRAVE (G.), Historiæ Rerum Naturalium Brasiliæ Libri VIII., a Joh. de Laët in ordinem digesti. Lugduni-Batavorum, 1648, fol. fig.

[2] DUTERTRE (J. BAPT.), Histoire générale des Antilles, etc., Paris, 1656–1671. 4 vols. 4to.

[3] MARTENS (FR.), Spitzbergische und Grönländische Reise-Beschreibung, im Jahr 1671, Hamburg, 1675, 4to. fig.

[4] BOCCONE (P. SILV.), Recherches et observations d'histoire naturelle touchant le Corail, etc., Paris, 1670, 12mo. fig.

SECTION III.

THE NATURALISTS OF THE EIGHTEENTH CENTURY.

Travellers,[1] observers,[2] and compilers[3] continue their work during this period in nearly the same spirit as towards the close of the preceding century, with this difference only, that the field of inquiry is gradually enlarging and extending. It is no longer the mere existence of curious animals and plants which attracts the attention: a desire of appreciating their relations to one another has evidently taken hold of the naturalists, and this aspiration reaches soon a climax in the publication of the "*Systema Naturæ*," the great work of this age, and the foundation of the lasting fame of Linnæus.

Though Linnæus himself added comparatively little to the general stock of information respecting the Acalephs, he had, nevertheless, as great an influence in preparing the way for their systematic arrangement as in other classes of the animal kingdom, by extending to them his binominal nomenclature. Yet, in the "*Systema Naturæ*" the members of the class of Acalephs are so far removed from one another as to show that Linnæus did not even dream of the true relations that unite the

[1] RUMPHIUS (G. EV.), D'Amboinsche Rariteitkammer, behelzende eene Beschryvinge van allerhande 200 Weeke als harde Schaalvischen, etc., Amsterdam, 1705, fol. fig. — SLOANE (HANS), A Voyage to the Islands of Madeira, Barbados, Nieves, St. Christopher's, and Jamaica, with the Nat. Hist. of the last of these Islands, etc., London, 1707–1725, 2 vols. fol. fig. — TOURNEFORT (JOS. PITTON DE), Relation d'un Voyage du Levant, Paris, 1717, 2 vols. 4to. fig. — FEUILLÉE (LOUIS), Journal d'observations faites sur les côtes orientales de l'Amérique et dans les Indes occidentales, Paris, 1714, 2 vols. 4to. fig. — Journal d'observations faites dans la nouvelle Espagne et aux iles de l'Amérique, Paris, 1725, 4to. — BROWN (PATR.), The Civil and Natural History of Jamaica, etc., London, 1756, fol. fig.

[2] MARSIGLI (L. F.), Brieve Ristretto del Saggio fisico intorno alla Storia del Mare, Venezia, 1711, 4to. fig. (French by Leclerc), Histoire physique de la Mer, Amsterdam, 1725, fol. fig. — RÉAUMUR (R. ANT. DE), Observations sur la formation du Corail et des autres productions appelées Plantes pierreuses, Mém. Acad. Sc. Paris, 1727. — CATESBY (MARK). Natural History of Carolina, Florida, and the Bahama Islands, etc., London, 1731–1743, 2 vols. fol. fig. col.; Appendix, London, 1748, fol. — PLANCUS (JANUS), De Conchis minùs notis in Littore Ariminensi, Venetiis, 1739, 4to. fig.; edit. altera Romæ, 1760, 4to. fig. — JUSSIEU (BERN. DE), Examen de quelques productions marines qui ont été mises au nombre des Plantes, et qui sont l'ouvrage d'une sorte d'Insecte de mer, Mém. Ac. Sc. Par. 1742, p. 290, fig. — BAKER (H.), Essays on the Natural History of the Polyps, London, 1743, 8vo. fig.

[3] BESLER (M. R.), Rariora Musei Besleriani quæ olim Bas. et M. R. Besler collegerunt, etc. Commentatio illustrata à J. H. Lochner, Nürnberg, 1716, fol. — SEBA (ALB.), Locupletissimi Rerum naturalium Thesauri accurata Descriptio et Iconibus artificiosissimis per universam Physices historiam (Lat. et Gall.), Amstelodami, 1734–1765, 4 vols. fol. fig.

Medusæ proper with the Siphonophoræ and the Hydroids.[1] Nevertheless, the share of attention bestowed upon the Acalephs is steadily increasing, and many valuable contributions to their history appear during this period; nay, several investigators begin to study with special care these and other soft-bodied animals, as well as the lower animals generally. The extraordinary disclosures of Trembley respecting the fresh-water Hydra,[2] and the discovery of the animal nature of the Corals by Peyssonnel,[3] had a great and lasting influence upon the progress of our knowledge of the lower animals; and even now their investigations are constantly alluded to as the starting points of a better era in the natural history of the Radiates. The paper of Réaumur upon Rhizostoma, and Plancus's delineation of the Marsupialis, were soon followed by Gronovius's[4] illustrations of several Medusæ; Baster's[5] descriptions and figures of many others; Bohadsch's[6] remarks upon Beroe, with a figure; Chanvallon's

[1] The history of the successive editions of the *Systema Naturæ* is instructive, on account of the progress Linnæus himself has made in fixing forever the nomenclature of Natural History. The first edition consisted of a single folio sheet, and has been republished by Ant. L. A. Fée in 1830, in Paris; the last edition published by Linnæus himself is the twelfth, printed in Stockholm in 1767, in 3 vols. 8vo.

[2] Trembley (Abr.), Mémoires pour servir à l'histoire d'un genre de Polypes d'eau douce, à bras en forme de cornes, Leyde, 1744, 4to. fig.

[3] Peyssonnel (J. A. de), Traité du Corail, etc., Phil. Tr. Roy. Soc. London, 1753, vol. 47, p. 445. The history of the views entertained at different periods respecting the nature of the Corals truly illustrates the progress of Natural History. At first considered as stones by Boccone (see note 4, p. 12) and Woodward (An Essay towards a Natural History of the Earth, London, 1695), they were regarded as plants by Marsigli (see note 2, p. 13), who was the first to observe, in 1706, what he called the *flowers of the Coral*. These supposed flowers, which are the individual polyps of the Coral stock, were at once considered as proving the vegetable character of the Coral, and even the greatest botanist of that time, Bernard de Jussieu, shared this view, until he had an opportunity of verifying for himself the accuracy of Peyssonnel's statements. Réaumur opposed Peyssonnel so pertinaciously that the extensive work of this accurate and ingenious observer never was published (see Flourens in Ann. des Sc. Nat. 2d ser. vol. 9, p. 334), and only an abstract of it appeared in the Transactions of the Royal Society of London. Had the whole been printed at once, naturalists would have known a century sooner, that the animals of the Stony Corals are homologous to the Actiniæ and Acalephs, for Peyssonnel does not hesitate to call them by the same name, *Orties*, Urticæ, though he also applies to them the name of Insects. The same volume of the Transactions of the Royal Society in which an abstract of Peyssonnel's work was published, also contains, p. 95, an interesting paper by Donati, entitled "New Discoveries relating to the History of Coral."

[4] Gronovius (L. Th.). His chief work is the Zoophylacium Gronovianum, exhibens Animalia, Quadrupeda, Amphibia, Pisces, Insecta, Vermes, Mollusca, Testacea et Zoöphyta quæ in Museo suo adservavit atque descripsit. Lugduni-Batavorum, 1763–1781, fol. fig.; but for the Acalephs consult his Observationes de Animalibus aliquot marinæ aquæ innatantibus, atque in littoribus Belgicis obviis, in Acta Helvetica, 1760, vol. 4.

[5] Baster (Joh). Opuscula subseciva, observationes miscellaneas de Animalculis et Plantis quibusdam marinis eorumque ovariis et seminibus continentia. Harlem, 1759–1765, 2 vols. 4to. fig.

[6] Bohadsch (J. B.), De quibusdam Animalibus

description of the Physalia[1] (which ought to be remembered in connection with the illustrations of Patrick Brown already quoted); Dana's[2] dissertation upon marine animals; and Slabber's delineations of several Medusæ.[3] Besides these, the more general works of Donati,[4] Hughes,[5] Hill,[6] Kalm,[7] Pontoppidan,[8] and Borlase,[9] also mention incidentally different kinds of Acalephs. The book of Borlase contains the first descriptions ever published of the Medusæ of the British coast accompanied with figures that may be recognized.

Notwithstanding this accumulation of observations, the real information respecting Medusæ thus far brought together is still scanty and disconnected. It consists chiefly of isolated facts without connecting links; and, though the modes of observing and describing are fast improving, we must pass on through another half century before we find naturalists applying to the study of Acalephs the accurate methods to which Zoölogy owes its present condition. Pallas[10] and Forskål[11] are the first who give fuller descriptions of Medusæ and attempt to distinguish their parts

marinis eorumque proprietatibus vel nondum vel minus notis, etc., Dresdæ, 1761, 4to. fig.

[1] CHANVALLON (THIB. DE), Voyage à la Martinique, contenant diverses observations sur la Physique, l'Histoire naturelle, l'Agriculture, les mœurs et les usages de cette île, Paris, 1763, 4to.

[2] DANA (J. P. M.), Dissertation sur les différences que présentent certains animaux marins connus sous la dénomination d'Ortie marine. Misc. Taurin, III. p. 206.—Description d'une espèce de Méduse, in Rozier, Journal de Physique, Indroduct. I. 1771, p. 141.

[3] SLABBER (MART.), Naturkundige Vergustigingen, Haarlem, 1778, 4to.

[4] DONATI (VITAL.), Saggio della Storia naturale marina dell'Adriatico, Venezia, 1750, 4to. fig. French translation: Essai sur l'Histoire Naturelle de la mer Adriatique, La Haye, 1758, 4to. fig.

[5] HUGHES (GRIFFITH), The Natural History of Barbados, London, 1750, fol. fig.—A letter concerning a Zoöphyton somewhat resembling the Flower of Marigold, Phil. Trans. XLII. p. 590. fig.

[6] HILL (J.), A Natural History of Animals, containing Descriptions of the Birds, Beasts, Fishes, Insects, and of the several Classes of Animalcula visible only by the assistance of microscopes, London, 1752, fol. fig.

[7] KALM (PETER), En Resa til Norra America, Stockholm, 1753–1761, 3 vols. 8vo. English translation: Travels in North America, containing its Natural History, etc., transl. by J. R. Forster, Warr. and Lond. 1770, 1771, 3 vols. 8vo.

[8] PONTOPPIDAN (ERIC), Norviges Natural Historie, etc., Kiöbenhavn, 1751–1753, 2 vols. 4to. fig. English: The Natural History of Norway, London, 1755, fol.

[9] BORLASE (WILL.), The Natural History of Cornwall, Oxford, 1758, fol. fig.

[10] PALLAS (PETER SIMON), Miscellanea Zoologica, quibus novæ imprimis atque obscuræ Animalium species describuntur, etc., Hagæ-Com., 1766. 4to. fig.—Spicilegia Zoologica, Berolini, 1767–1780; 14 Fascic. 4to. fig.; German translation by E. G. Baldinger: Naturgeschichte merkwürdiger Thiere, etc., Berlin, 1769–1778, 10 vols. 4to. fig.—Elenchus Zoophytorum, sistens Generum adumbrationes generaliores et Specierum cognitarum succinctas descriptiones, cum selectis auctorum Synonymis, Hagæ-Com., 1766, 8vo.

[11] FORSKÅL (P.), Descriptiones Animalium, Avium, Amphibiorum, Piscium, Insectorum, Vermium, quæ in Itinere orientali observavit; edidit C. Niebuhr, Hafniæ, 1775, 4to.—Icones Rerum naturalium quas in Itinere orientali depingi curavit; ed. C. Niebuhr, Hafniæ, 1776, 4to.

with scientific precision; and their followers, O. F. Müller[1] and O. Fabricius,[2] contribute many valuable additions. Thus far, whenever illustrations had been added to the descriptions of animals, they were chiefly wood-cuts, or engravings printed in black. But in the year 1776, O. F. Müller began the publication of a series of truly magnificent colored plates, painted and engraved by his brother, which appeared in successive numbers under the title of Zoölogia Danica. This work forms an era in Natural History, and has set an example, to which we are indebted for all the costly and ever improving colored illustrations of this kind during the last eighty years. To this day the Zoölogia Danica is indispensable to the student of marine animals. It contains a considerable number of good figures of Acalephs, including true Medusæ, Beroids, and Hydroids. Henceforward, the number of Medusæ known is not only much larger than before, but they are described with much greater fulness and nicety. At the same time, the investigations of Spallanzani[3] upon the most delicate problems in the structure of animals excited universal attention by the extraordinary disclosures to which they led. Cook's voyages also stimulated inquiries into the animals of every part of the globe; and Banks, Solander, and Forster, who had made the voyage round the world with the great English captain, describe, with the coöperation of Ellis, the most remarkable natural productions brought home

[1] MÜLLER (O. FR.), Zoölogiæ Danicæ Prodromus, seu Animalium Daniæ et Norvegiæ indigenorum characteres, nomina, etc., Hafniæ, 1776, 8vo. — Zoologia Danica, seu Animalium Daniæ et Norvegiæ rariorum Descriptiones et Historia, Hafniæ et Lipsiæ, 1779–1784, 2 vols. 8vo., and Hafniæ, 1788–1806, 4 vols. fol. fig., with additions by Abilgaard, Holton, Vahl, and J. Rathke.

[2] FABRICIUS (O.), Fauna Grœnlandica, systematicè sistens Animalia Grœnlandiæ occidentalis, hactenus indagata, Hafniæ et Lipsiæ, 1780, 8vo. fig. This work is particularly important to the naturalists of New England, as it contains the first descriptions of many marine animals found on our own coasts.

[3] SPALLANZANI (LAZ.), Prodromo di un opera sopra le Riproduzioni animali, Modena, 1768, 4to. French translation by Bonnet: Programme ou Précis d'un Ouvrage sur les Reproductions animales, Genève, 1768, 8vo. English translation: An Essay on Animal Reproductions, etc., London, 1769, 8vo. Latin edition: Prolusio Operis de Animalibus microscopio visibilibus, Mutinæ, 1770, 4to. — Saggio di Osservazioni microscopiche, concernenti il Sistema della Generazione di Needham e Buffon, Modena, 1765, 4to. French translation by Regley: Nouvelles Recherches sur les Découvertes microscopiques et la Génération des Corps organisés, London et Paris, 1769, 2 vols. 8vo. fig. — Lettera sulla Fecondazione artifiziale, e sull' Elettricità delle Torpedini; Opusc. Scelt. 1783. — Risultati di Esperienze sopra la Riproduzione della Testa nelle Lumache terrestri; Mem. Soc. Ital. I. p. 581; II. p. 506, fig. — Sopra gli' Animali delle Infusioni, e sui nuovi Pensamenti, in proposito di Needham; Giorn. d'Ital. III. — Lettera relativa à diverse Produzioni marine; Opusc. Scelt. VII. — Opuscoli di Fisica animale e vegatibile, Modena, 1776, 2 vols. 8vo. fig.; Venezia, 1782, 3 vols. 8vo. French translation by Senebier: Opuscules de Physique animale et végétale, etc., Genève, 1777; Paris, 1787, 2 vols. 8vo. English Translation, London, 1784, 2 vols. 8vo. — Dissertazioni di Fisica animale e vegetabile, Modena, 1780, 2 vols. German translation: Abhandlungen über einige Gegenstände aus der animalischen und vegetabilischen Naturkunde, Leipzig, 1778, 2 vols. 8vo.

by these expeditions. Cavolini[1] investigates the minute animals of the Mediterranean, Pennant[2] those of the coast of England, Forskål and Löfling[3] those of the Red Sea and of New Spain, Swartz[4] those of the Antilles, Modeer[5] those of the Northern Ocean, Scopoli[6] and Olivi[7] those of the Adriatic, and Macri[8] those of the Bay of Naples. Everywhere, stimulated by the influence of their great teacher, we find the pupils of Linnæus foremost in this race for knowledge. The harvest of Acalephs is, however, still scanty; and the works of Pallas, Forskål, O. F. Müller, and O. Fabricius, are the only ones deserving now special attention, and this chiefly on account of the influence their accurate descriptions had upon the progress of that branch of Zoölogy. Pallas, in his Zoölogical Miscellanies, published in 1776, is the first who gives accurate figures of Hydroids, without suspecting, however, that they have the least relation to the Medusæ proper.

The use of the microscope having become more frequent, objects are not only examined with more care and accuracy than before, but also frequently magnified, so as to give a more satisfactory view of their parts. The treatise of Ellis[9] on Corallines is, in that respect, a master-work, to this day indispensable to the student of the Hydroids; and next to it must be ranked the work of Cavolini.

The last quarter of this century is marked by various compilations of the labors

[1] CAVOLINI (FIL.), Memorie per servire alla Storia dei Polipi marini, Napoli, 1785, 4to. fig. German translation by W. Sprengel: Abhandlungen über Pflanzenthiere des Mittelmeeres, Nürnberg, 1813, 4to. fig. — Nuove Ricerche sulle Gorgonie e sulle Madrepore, Napoli, 1785, 4to. fig. German translation by Zimmermann, Berlin, 1792, 8vo. — Memoria sulla Generazione dei Pesci e dei Granchi, Napoli, 1787, 4to. German translation by Zimmermann: Abhandlung über die Erzeugung der Fische und der Krebse, Berlin, 1792, 8vo. fig.

[2] PENNANT (THOMAS), British Zoölogy, Lond. 1761, 1 vol. fol.; 1768–1769, 3 vols. 8vo.; 103 additional plates, 1770; 1776–1777, 4 vols. 8vo.; 1812, 4 vols. 8vo.

[3] LÖFLING (PETER), Iter hispanicum; eller Resa til spanska Länderna uti Europa, och America, Stockholm, 1768, 8vo. fig. German translation by Al. B. Kölpin: Reise nach den spanischen Ländern, Berlin, 1776, 1 vol. 8vo. fig.

[4] SWARTZ (OLOF), *Medusa unguiculata* och *Actinia pusilla* upptäckta och beskrifna, Vet. Acad. Handl. 1788, p. 198.

[5] MODEER (ADOLPH), Om Slägtet Sjokalf, Medusa, in Svenska Vetenskaps Academiens Nya Handlingar, Vol. XII. 1791.

[6] SCOPOLI (J. ANT.), Introductio ad Historiam naturalem, sistens genera Lapidum, Plantarum et Animalium, etc., in tribus divisa, subinde ad leges Naturæ, Pragæ, 1777, 8vo. — Anni historico-naturales, IV. Lipsiæ, 1769–1772, 5 vols. 8vo.

[7] OLIVI (GIUS.), Zoologia Adriatica, ossia Catalogo ragguionato degli Animali del Golfo e delle Lagune di Venezia, Bassano, 1792, 4to. fig.

[8] MACRI (SAV.), Nuove Osservazioni intorno la Storia naturale del Polmone marino degli Antichi, Napoli, 1779, 12mo.

[9] ELLIS (J.), An Essay towards a Natural History of the Corallines and other Marine Productions of the like kind, commonly found on the coasts of Great Britain and Ireland, etc., London, 1755, 4to. fig. French translation: Essai sur l'Histoire Naturelle des Corallines, etc., LaHaye, 1758, 4to. fig. German translation: Versuch einer Naturgeschichte der Korall-Arten und anderer solcher Meerkörper, Nürnberg, 1764, 4to. fig.

of preceding years. Several works give such *résumés;* but they only serve to bring more glaringly to light the deficiency of the information upon which a natural system might be built. The fullest of these compilations is the thirteenth edition of the Systema Naturæ of Linnæus, published between the years 1783 and 1793 by J. Fr. Gmelin.[1] Another is the Encyclopédie Méthodique, published by an association of naturalists in Paris in 201 vols. 4to., between the years 1782 and 1832, with a view of presenting a complete cyclopædia of all that was known at the time in every branch of Natural History. The Acalephs were compiled by Bruguière. Nearly all the illustrations published by earlier observers are here reproduced, but nothing new is added. These publications have lost their merit now, and can only be used as books of easy reference to the scattered descriptions and figures of previous writers.

Besides the publication of these systematic cyclopædias, we have also to notice the scientific dictionaries of the time, which aimed at giving similar, though more condensed, accounts of the knowledge of their age,[2] but did not add much to the real progress of science. Not so with the proceedings and transactions of learned societies;[3] for in their volumes we find innumerable original papers in which the discoveries of the day are recorded, and among them, here and there, some notices bearing more or less directly upon the natural history of the Acalephs. The most important of them have already been quoted.

SECTION IV.

THE SYSTEMATIC WRITERS AND ANATOMISTS.

With the beginning of the nineteenth century opens another era in the history of Acalephs. Now, for the first time, are successful attempts made to combine systematically the investigations of the past, and every year adds new materials to

[1] Gmelin (J. Fr.), Car. a Linné Systema Naturæ per Regna tria Naturæ, etc., editio decima tertia, aucta et reformata, Leipzig, 1788–1793, 7 vols. 8vo.

[2] Valmont de Bomare, Dictionnaire raisonné universel d'histoire naturelle, Paris, 1765–1768, 5 vols. 8vo.; 2e édit. 1768, 1769, 12 vols. 8vo.; 3e édit. 1775, 6 vols. 8vo.; 4e édit. Lyon, 1791, 15 vols. 8vo.

[3] The most valuable of these transactions are those of the Royal Society of London, of the Academia Naturæ Curiosorum, and of the Academy of Sciences of Paris. The former are published under the title of Philosophical Transactions of the Royal Society, the latter as Mémoires de l'Académie des Sciences de Paris, and those of the Academia Naturæ Curiosorum appeared, first under the title Miscellanea, next as Ephemerides, and afterwards as Acta, and are now continued as Nova Acta Academiæ Cæsareo-Leopoldinæ Naturæ Curiosorum.

the edifice. Thus far all the Discophoræ, whether covered-eyed or naked-eyed, had been placed in one and the same genus, and even the Ctenophoræ were associated with them. Only a few species of Siphonophoræ were referred to other genera; but then these were not placed in close proximity with the Medusæ proper, and the Hydroids were unhesitatingly referred to the class of Polyps, or at least arranged among them. The whole number of genera distinguished among the animals now referred to the class of Acalephs amounted only to thirteen in 1801; namely, Beroe *Brown*, Medusa *L.*, Physalia *Lamrk.* (first called Arethusa by P. Brown, then Physalis by Osbeck and Salacia by Linnæus), Velella *Lamrk.*, and Porpita *Lamrk.* (first called Phyllodoce and Thalia by P. Brown), Gleba *Brug.*, Physophora *Forsk.*, Lucernaria *Müll.*, Hydra *L.*, Coryne *Gärtn.*, Tubularia *L.*, Sertularia *Lamrk.*, Millepora *L.*

Owing to the greater number of Medusæ now known, including species from distant parts of the world, and also to the discovery of numerous animals more or less closely allied to them, it has become necessary to institute comparisons between the animals of this class and the representatives of other classes, which were not even suggested before. This is therefore truly the age of Comparative Natural History; and a new science, Comparative Anatomy, arises with it, by the gigantic labors of the scientific hero of modern times.

Péron and LeSueur[1] open this period with investigations upon a far greater number of species of Acalephs than had been observed by all the investigators of former ages taken together. Engaged as naturalists in the expedition of Captain Baudin to the South Seas during the first four years of this century, they had the fullest opportunities of examining these animals alive; and LeSueur, with incomparable skill, reproduced their delicate appearance in a series of colored plates, so magnificent and of such costly execution, that to this day a small part of them only have been published. But these illustrations were deposited in the library of the Jardin des Plantes in Paris, and have been extensively used by French naturalists who have written upon Acalephs during the last thirty years. They are referred to, and partly copied by, de Blainville in his Manuel d'Actinologie.

[1] PÉRON (FR.) ET LESUEUR (C. A.), Voyage de découvertes aux Terres Australes, pendant les années 1800–1804, Paris, 1807–1816, 3 vols. 4to. fig. — Histoire générale et particulière de tous les Animaux qui composent la famille des Méduses, Ann. Mus. XIV. p. 218. — Tableau des Caractères génériques et spécifiques de toutes les espèces de Méduses connues jusqu'à ce jour. Ann. Mus. XIV. p. 325. — Sur les Méduses du genre Equorée, Ann. Mus. XV. p. 41. — LeSueur by himself published two papers relating to the Acalephs and allied animals: Mémoire sur quelques nouvelles espèces d'Animaux Mollusques and Radiaires recueillies dans la Méditerranée près de Nice, Journal de Physique. vol. 77, p. 119, and Mémoire sur l'organisation des Pyrosomes et sur la place qu'ils doivent occuper dans une classification naturelle, Journal de Physique, vol. 80, p. 413. He was the first to suggest that the Siphonophoræ are compound animals, — an opinion now almost universally admitted.

Lesson used them while preparing his Prodrome d'une Monographie des Méduses and his Histoire naturelle des Acalèphes; and Milne-Edwards has caused some to be engraved for the new illustrated edition of Cuvier's Règne Animal.[1] The publications of Bory de St. Vincent[2] and of Tilesius,[3] which next follow, are interesting as furnishing the first indications upon the Diphyes; while those of Scoresby,[4] Otto,[5] VanHasselt,[6] Eichwald,[7] DeHaan,[8] Guilding,[9] Piet,[10] Baird,[11] Woodward,[12] von Olfers,[13] Meyen,[14] Patterson,[15] Forbes, Goodsir,[16] and Hyndman,[17] add new species to our lists, and new facts respecting species already known. Bosc's[18] Natural History of the Worms also contains some valuable remarks. On account of his residence upon our southern coasts, the works of Bosc are interesting to American naturalists.

While Péron and LeSueur and their successors were thus steadily enlarging the range of our knowledge by special investigations, the systematic writers of this period began to perceive more and more clearly the general affinities of these animals;

[1] CUVIER (G.), Le Règne animal distribué d'après son organisation, pour servir de base à l'Histoire naturelle des animaux, et d'introduction à l'Anatomie comparée; édition accompagnée de planches gravées, par une réunion de disciples de Cuvier, publiée par Fortin, Masson & Co., Paris, 8vo. since 1836. The volume containing the Acalephs is edited by Milne-Edwards.

[2] BORY DE SAINT-VINCENT (J. B. G.), Voyage dans les quatre principales îles des mers d'Afrique, Paris, 1804, 3 vols. 8vo. avec atlas.

[3] TILESIUS (W. G.), Naturhistorische Früchte der ersten kaiserlich-russischen Weltumsegluug, Petersburg, 1813, 4to.

[4] SCORESBY (W.), An Account of the Arctic Regions, Edinburgh, 1820, 2 vols. 8vo. fig.

[5] OTTO (AD. W.), Conspectus animalium quorumdam maritimorum nondum editorum, Vratislaviæ, 1821, 4to. fig. — Beschreibung einiger neuer Mollusken und Zoophyten, N. Act. Nat. Cur. XI. 2, p. 273, fig.; Isis, 1824, VI. p. 626.

[6] VANHASSELT, Ueber Physalia, Brief an Prof. VanSwindern, Isis, 1823, p. 1413.

[7] EICHWALD (ED.), Observationes nonnullæ circa fabricam Physaliæ, Mém. Acad. Petersb. 1824, IX. p. 455.

[8] DEHAAN (W.), Verhandeling over de Rangschikking der Velellen, Porpiten und Physalien, Bijdrag Natuur. Wetens, 1827, II. p. 489.

[9] GUILDING (LANSD.), Mollusca Caribbæana, Zool. Journ. 1827, III. p. 403.

[10] PIET, Description de la grande Physale et d'une curieuse espèce de Médusaire, trouvées sur les côtes de Bretagne, Lyc. Armor. XII. p. 189.

[11] BAIRD (DR.), On the Luminousness of the Sea, Mag. Nat. Hist. 1830, III.

[12] WOODWARD (SAM.), On the Luminosity of the Sea, Mag. Nat. Hist. 1831, IV. p. 285.

[13] VON OLFERS, Ueber die grosse Seeblase, Physalia Arethusa, und die Gattung der Seeblasen im Allgemeinen. Ak. Wiss. Berlin, 1831.

[14] MEYEN (F. J.), Beiträge zur Zoologie; N. Act. Nat. Cur. XVI. suppl. I. 1834.

[15] PATTERSON (ROBERT), Description of the Cydippe pomiformis (Beroë ovata, Flem.), with Notice of an apparently undescribed Species of Bolina, also found on the Coast of Ireland, Proc. Roy. Irish Acad. 1839, p. 237.

[16] FORBES (EDW.), Contributions to British Actinology, An. and Mag. Nat. Hist. 1841, VII. p. 81. — FORBES (EDW.) and GOODSIR (J.), On the Corymorpha nutans, Ann. and Mag. Nat. Hist. 1840, V. p. 309.

[17] HYNDMAN (G. C.), On the Occurrence of the genus Diphya on the Coast of Ireland; Ann. and Mag. Nat. Hist. 1841, VII. p. 164.

[18] BOSC (L. A. G.), Histoire naturelle des Vers, Paris, 1802, 18mo. 3 vols. fig.

and the works of Cuvier,[1] Blumenbach,[2] Duméril,[3] Lamarck,[4] Oken,[5] Goldfuss,[6] and Schweiger,[7] suggest successive improvements in their classification. There remains, however, so much uncertainty respecting the general characteristics of the different groups of Radiates or Zoophytes, that naturalists disagree even as to the classes that should be referred to this type. Cuvier, for instance, unites the Intestinal worms and the Infusoria with the Radiates, while DeBlainville refers the first to the Articulata, and the second to his Microzoaires. Cuvier also at first unites the Actiniæ with the Acalephs, while he afterwards separates them.[8] Even the limits between the Radiates and the lower Mollusks are ill-defined, so that Sa-

[1] CUVIER (GEORGE), Tableau élémentaire de l'Histoire naturelle des animaux, Paris, 1798, 8vo. fig. — Le Règne animal distribué d'après son organisation, pour servir de base à l'Histoire naturelle des animaux et d'introduction à l'Anatomie comparée, Paris, 1817, 4 vols. 8vo. fig.

[2] BLUMENBACH (J. FR.), Handbuch der Naturgeschichte, Götting. 1779, 8vo. fig.; Götting. 1825 (11th ed.), French transl. by Artaud, Manuel d'Histoire Naturelle, Paris, 1803, 2 vols. 8vo. fig.

[3] DUMÉRIL (A. M. C.), Zoologie analytique, ou Méthode naturelle de Classification des Animaux, Paris, 1806, 8vo.

[4] LAMARCK (J. B. DE), Histoire naturelle des animaux sans vertèbres, présentant les caractères généraux et particuliers de ces animaux, leur distribution, etc., Paris, 1815–1822, 7 vols. 8vo.; (Sec. édit. augmentée de notes par MM. DESHAYES et MILNE-EDWARDS), Paris, 1835–1843, 10 vols. 8vo. — His Cours de Zoologie is also important.

[5] OKEN (LOR.), Lehrbuch der Naturgeschichte, Weimar, 1816, 2 vols. 8vo. — Allgemeine Naturgeschichte, Stuttgart, 1833–1842, 14 vols. 8vo. fig.

[6] GOLDFUSS (G. A.), Handbuch der Zoologie, Nürnberg, 1820, 2 vols. 8vo.

[7] SCHWEIGER (A. FR.), Handbuch der Naturgeschichte der skelettlosen ungegliederten Thiere, Leipz. 1820, 8vo. One of the most valuable textbooks of that period. It is full of original observations.

[8] At the time Cuvier characterized the Acalephæ as a distinct class among Radiata in the first edition of the Règne Animal, published in 1817, the great French naturalist included among them the Actiniæ, now generally referred to the class of Polypi. To this class he himself removed them in the second edition of that important work. It is a remarkable circumstance, that no advance was made towards a natural classification of the Acalephs from the days of Aristotle to the period when Savigny, Schweiger, Cuvier, and others attempted to improve our knowledge of the lower animals. In the first edition of the Règne Animal we find the same distinction introduced among the Acalephs, between the free and the fixed Acalephs, which Aristotle had adopted; whilst a number of animals which must be united with the Acalephs are still left among the Polyps, as they were centuries before. From the beginning, then, the class of the Acalephæ was far from being circumscribed within natural limits; and we shall presently see, that it has required the indefatigable investigations of some of the ablest observers for about a century, before the natural affinities of the animals belonging to this class were fully appreciated. It is one of the most instructive lessons for a student of nature to trace the gradual progress of the discoveries which have led to the views now prevailing respecting these animals, as they involve discussions upon all the fundamental principles of Zoölogy. Instead, therefore, of giving only the results of my own studies of the Acalephs, I will attempt, in this work, to trace also this successive growth of our present knowledge, with the special view of teaching the young naturalists of America how to proceed in their own researches.

vigny's[1] admirable researches upon compound Ascidians may be said to have contributed largely to the progress of the natural history of Acalephs. The same is true of the papers of Chamisso[2] and Cuvier[3] upon the Salpæ. The attempt of Latreille[4] to characterize the natural families of the animal kingdom did nothing towards improving the classification of the Acalephs; but Van der Hoeven gave a good account of what was then known about them.[5] In the special Faunæ of Risso[6] and Fleming,[7] there is much to be gleaned. The paper of Rang[8] deserves especially to be noticed, as it is very important for the study of the Beroids.

The interest excited by the success attending a combination of political objects with scientific explorations in the voyage of Captain Baudin soon led other powers to imitate the example of the French government, and the result has been a series of invaluable contributions to science. The most important of these scientific exploring expeditions are as follows: that of Admiral Krusenstern, with Langsdorf and Tilesius as naturalists;[9] the two voyages of Captain Kotzebue,[10] with Chamisso and Eschscholtz as naturalists; then the voyage of Captain Freycinet[11] in the Uranie

[1] SAVIGNY (JULES-CÉSAR), Mémoires sur les animaux sans vertèbres, Paris, 1816, 2 vols. 8vo. See also the great work upon Egypt published by order of Napoléon after the memorable campaign of 1798.

[2] CHAMISSO (ALBERTUS DE) ET EYSENHARDT (C. G.), De Animalibus quibusdam e classe Vermium Linnæana, in circumnavigatione terræ, auspicante comite N. ROMANZOFF, duce OTT. DE KOTZEBUE, ann. 1815–1818 peractâ, observatis. Act. N. Nat. Cur. 1819, 4to.

[3] CUVIER (G.), Mémoire sur les Thalides et les Biphores, Ann. du Mus. 1804, IV. p. 360. — Mémoire sur les Ascidies, Mém. du Mus. 1815, II. p. 10. Both these papers are reprinted in Mémoires pour servir à l'Histoire et à l'Anatomie des Mollusques, Paris, 1817, 4to. fig.

[4] LATREILLE (P. A.), Familles naturelles du Règne animal, exposées successivement et dans un ordre analytique, avec l'indication de leurs genres, Paris, 1825, 8vo.

[5] VAN DER HOEVEN (JOHAN.), Tabula Regni animalis, additis Classium Ordinumque characteribus, Lugd.-Bat., 1828, fol. — Handboek der Dierkunde, Delft, 1827, 8vo.; Rotterdam, 1828, 3d edit., 2 vols. 8vo. — English translation: Handbook of Zoölogy, by the Rev. W. Clark, Cambridge, 1856–1858, 2 vols. 8vo. fig. This is the best modern text-book of special Zoölogy.

[6] RISSO (A.), Histoire naturelle des principales productions de l'Europe méridionale, particulièrement de celles des environs de Nice et des Alpes maritimes, Paris, 1826, 5 vols. 8vo. fig.

[7] FLEMING (JOHN), A History of British Animals, exhibiting their Descriptive Characters, Edinburgh, 1828, 8vo. — The Philosophy of Zoölogy, London, 1822, 2 vols. 8vo.

[8] RANG (SANDER), Etablissement de la famille des Béroïdes dans l'ordre des Acalèphes libres, et Description de deux genres nouveaux qui lui appartiennent, Mém. Soc. Hist. n. Par. IV. p. 166. fig.; Férussac, Bull. 1829, 17, p. 141.

[9] See note 3, p. 20.

[10] KOTZEBUE (OTTO), Voyage pittoresque autour du monde, sur le brick le Rurick, en 1815–1818, Paris, 1821–1823, fol. — Neue Reise um die Welt in den Jahren 1823–1826, Weimar, 1830, 2 vols. 8vo. fig.

[11] FREYCINET (L. DE), Voyage autour du monde sur les corvettes l'Uranie et la Physicienne, pendant les années 1817–1820, Paris, 1824, 8 vols. 4to. and 4 vols. atl. fol.

and Physicienne, with Quoy and Gaimard[1] as naturalists; that of Captain Duperrey[2] in the Coquille, with Lesson and Garnot[3] as naturalists; the two voyages of Captain Dumont d'Urville,[4] the first in the Astrolabe with Quoy and Gaimard,[5] and the second in the Astrolabe and Zélée with Hombron and Jacquinot, as naturalists; that of Captain LaPlace[6] in the Favorite, with Eydoux and Baume as naturalists; that of Captain Vaillant[7] in the Bonite, with Eydoux and Souleyet as naturalists; and that of Captain Dupetit-Thouars[8] in the Venus. These publications are truly admirable in their execution, and that of the Astrolabe particularly important for the Acalephs. The more recent exploring expeditions fitted out by the United States and in England can fairly be placed by the side of them.[9] In this connnection it is fitting to remember the great works of Humboldt, the scientific expedition to Egypt, those in Morea and Algiers, and the many more recent explorations in almost every part of the world.

[1] QUOY ET GAIMARD, Zoologie du Voyage de l'Uranie, sous les ordres du CAPITAINE FREYCINET, de 1817 à 1820, Paris, 1824, 4to. atl. fol.

[2] DUPERREY (L. J.), Voyage autour du monde sur la corvette la Coquille, pendant les années 1822–1825, Paris, 1828, 6 vols. 4to. and 4 vols. atl. fol.

[3] LESSON (R. P.) ET GARNOT (P.), Zoologie du Voyage autour du monde exécuté sur la Corvette la COQUILLE par L. DUPERREY commandant de l'Expédition, pendant les années 1822–1825, Paris, 1829, 2 vols. 4to. atl. fol.

[4] DUMONT-D'URVILLE (J.), Voyage autour du monde et à la recherche de la Pérouse, sur la corvette l'Astrolabe, pendant les années 1826–1829, Paris, 1830, et suiv., 6 vols. 8vo. Atl. fol. — Voyage au Pole Sud and dans l'Océanie sur les corvettes l'Astrolabe et la Zélée, pendant les années 1837–1840, Paris, 34 vols. 8vo. atl. fol.

[5] QUOY ET GAIMARD, Zoologie du Voyage de l'Astrolabe, sous les ordres du CAPITAINE DUMONT D'URVILLE, pendant les années 1826–1829, Paris, 1830–1833, 5 vols. 8vo. atl. fol. — Observations Zoologiques faites à bord de l'Astrolabe en Mai 1826, dans le Détroit de Gibraltar, Ann. Sc. n. 1827, X. pp. 5, 172, 225, fig.

[6] LAPLACE (C. P. TH.), Voyage autour du monde par les mers de l'Inde et de la Chine, sur la corvette la Favorite, pendant les années 1830–1832, Paris, 1833–1839, 5 vols. 8vo. Histoire naturelle, vol. 5, par Eydoux et Baume.

[7] VAILLANT, Voyage autour du monde, sur la corvette la Bonite, pendant les années 1836 et 1837, Paris, 1838 et suiv. Zoologie par Eydoux et Souleyet, 2 vols. 8vo. et atl. fol.

[8] DUPETIT-THOUARS, Voyage autour du monde sur la frégate la Vénus pendant les années 1837–1839, Paris, 1840, et suiv. 10 vols. 8vo. atl. fol. Zoologie par Isid. Geoffrey St. Hilaire et Valenciennes, 1 vol. 8vo. et atl. fol.

[9] BELCHER (E.), Narrative of a Voyage round the World in the Sulphur, 1836–1842, London, 1843, 2 vols. 8vo. — The Zoölogy of the Voyage of the Sulphur, by R. B. Hinds, London, 1845, 2 vols. 4to. — Narrative of the Voyage of the Samarang among the Islands of the Eastern Archipelago, 1843–1846, London, 1848, 2 vols. 8vo. — The Zoölogy by Adams and Reeve. — FITZROY (ROBERT), Proceedings of the Beagle's Second Voyage to South America, 1831–1836, London. — The Zoölogy of the Voyage of the Beagle, edited and super. by Ch. Darwin, London, 1839–1843, 5 vols. 4to. — WILKES (CH.), Narrative of the United States Exploring Expedition during the Years 1838–1842, Philadelphia, 1845, 3 vols. 8vo. — The Zoölogy, Zoophytes, and Crustacea, by J. D. Dana.

In the year 1829, Eschscholtz,[1] who had made two voyages round the world with Captain Kotzebue, published his system of the Acalephs, the most important work yet published upon this class, as it embodies not only the results of all the investigations of his predecessors, but presents, with great fulness and precision, original investigations made by himself upon all the members of this class now referred to it, with the sole exception of the Hydroids. The figures, though mere outlines, are invaluable for their accuracy. In the following year DeBlainville published a general account of the Zoöphytes, in which the Acalephs occupy a large place; but it can hardly be said to mark a progress in our science, notwithstanding the many additions it contains in the details, for De Blainville[2] has been led in the classification to make changes which are unjustifiable, and to remove from among the Acalephs a large number of genera which undoubtedly belong to this class. The more recent publications of systematic importance are those of Mertens,[3] Brandt,[4] and Lesson;[5] and with the latter ends fairly the period of the purely descriptive history of Acalephs. There are, still, many papers published at a later

[1] ESCHSCHOLTZ (FR.), System der Acalephen, eine ausführliche Beschreibung aller medusenartigen Strahlthiere, Berlin, 1829, 4to. with fourteen plates. Eschscholtz made two voyages round the world, the first in 1815–1818 as physician on board the brig Rurick under the command of Captain Otto von Kotzebue, while Chamisso was naturalist to the expedition. He has contributed several papers to the report of this voyage. The results of the second voyage, in the years 1823–1826, on board the Predpriactië sloop of war, under the command of the same distinguished seaman, are particularly interesting to American naturalists, as, during a prolonged stay upon the north-west coast of this continent, Eschscholtz visited California, and discovered a great many curious animals peculiar to our western Fauna, which are described for the first time in the "Zoologischer Atlas, enthaltend Abbildungen und Beschreibungen neuer Thierarten, während des Flottecapitains v. Kotzebue's 2ter Reise um die Welt, von Dr. Friedr. Eschscholtz, Berlin, 1829–1833, in 5 Hefte," the last of which was edited by Rathke, after the author's death. The name of Eschscholtz is familiar to every lover of flowers, in the elegant plant that now adorns our gardens and which bears his name, the Eschscholtzia of California. The scientific results of the first voyage of Kotzebue were in part published by *Chamisso and Eysenhardt* in N. Act. Nat. Cur. X. 1821.

[2] BLAINVILLE (H. D. DE), Article Zoophytes in Nouveau Dictionnaire d'histoire naturelle, Paris, 1830. Republished under the title of Manuel d'Actinologie, Paris, 1834, 2 vols. 8vo. fig.

[3] MERTENS (H.), Beobachtungen über die Beroëartigen Acalephen, Mém. Acad. Pétersb. 1833.

[4] BRANDT (J. F.), Ausführliche Beschreibung der von C. H. MERTENS beobachten Schirmquallen, etc., Petersb. 1838, 4to. fig. col., Mém. Acad. Pét. sér. 6, 11. Also Prodromus, etc. 1835.

[5] LESSON, Histoire naturelle des Zoophytes, Acalèphes, Paris, 1843, 1 vol. 8vo. fig. — Centurie Zoologique, Paris, 1830, 8vo. fig. — Tableau de la famille des Zoophytes Béroides, Ann. Sc. Nat. V. p. 254, 1836. Translated in Proc. Zool. Soc. III. p. 2. — Prodrome d'une Monographie des Méduses, in-4to. de 62 pages, Rochefort, juin, 1837. Edw. Forbes questions the existence of this work; but it was really published, in the shape of autographed sheets, of which, however, a very small number of copies were issued. I myself used it when preparing the Nomenclator Zoologicus. The copy I saw belongs to Duméril.

date, which, however, contain so little concerning the structure or embryonic development of the Acalephs, that they may fairly be enumerated here. Such are Peach's Observations on the Luminosity of the Sea;[1] Lütken's[2] classification of the Medusæ; Forbes and Goodsir's[3] description of new species; F. Müller's[4] Medusæ of Santa Catharina; Alders's[5] new British Hydroids, and Catalogue of the Zoöphytes of Northumberland; Gould's enumeration of those of Massachusetts;[6] Sars's, and Leuckart's Contributions to those of the Mediterranean;[7] Gosse's Rambles along the British shores,[8] etc.; the Dictionnaire des Sciences Naturelles,[9] the Dictionnaire Classique,[10] Ersch and Gruber's Encyclopädie,[11] the Isis of Oken, the Annales des Sciences Naturelles, the Archiv für Naturgeschichte, the Zeitschrift für wissenschaftliche Zoölogie, Müller's Archiv, the Annals and Magazine of Natural History; and the innumerable smaller periodical publications, and proceedings of learned societies of our time, should also be consulted. Enough is now known of the Acalephs to show, that, since they undergo the most extraordinary changes during their life, the history of no one species can be considered as satisfactory before it has been traced in all its conditions. Henceforth, mere descriptions of isolated forms can have but a very limited interest. The time when it could be thought sufficient merely to draw up a diagnosis, in order to characterize a species, is indeed gone for the Acalephs, and, I trust, for other classes of animals also. This great change in the requirements of our science was chiefly brought about by the investigations related in the next section.

[1] PEACH (CH. W.), Observations on the Luminosity of the Sea, with Descriptions of the several Objects which cause it, Ann. and Mag. Nat. Hist. 1850, VI. p. 425.

[2] LÜTKEN (C. F.), Ueber die systematische Gruppirung der Medusen, Vidensk. Meddels. 1849–1850, p. 15. I only know this paper from the abstract in Arch. f. Naturg. 1854, XX. p. 424.

[3] FORBES (EDW.) and GOODSIR (J.), On some remarkable marine Invertebrata, new to the British Seas, Trans. Roy. Soc. Edinb. 1851, XX. p. 307.

[4] MÜLLER (FR.), Zwei neue Quallen von Santa Catharina (Brasilien), Abh. Nat. Ges. Halle, 1859, V. p. 1.

[5] ALDER (JOS.), Notice of some new Genera and Species of British Hydroid Zoophytes, Ann. and Mag. Nat. Hist. 1856, XVIII. p. 353 and 439. — Catalogue of the Zoophytes of Northumberland and Durham, Trans. Tyneside Natur. Club; in abstract in Micr. Journ. V. p. 242.

[6] GOULD (A. A.), Report on the Invertebrata of Massachusetts, Boston, 1841, 8vo.

[7] SARS (M.), Bidrag til kundskaben om Middelhavets Littoral-Fauna, Reisebemärkninger fra Italien, Christiania, 1857, 8vo. Abstracts of it may be found in Arch. Naturg. 1858, II. p. 156 and 163. — LEUCKART (R.), Beiträge zur Kenntniss der Medusenfauna von Nizza, Arch. Naturg. 1856, I. p. 1.

[8] GOSSE (TH. H.), Naturalist's Rambles on the Devonshire Coast, London, 1853, 1 vol. 8vo. fig. — Tenby, a Sea-side Holiday, London, 1856, 1 vol. 8vo. fig.

[9] Dictionnaire des Sciences Naturelles, publié par les Professeurs du Jardin du Roi, Paris et Strasbourg, 1816–1829, 60 vols. 8vo. fig.

[10] Dictionnaire Classique d'Histoire naturelle, etc., Paris, 1824–1830, 17 vols. 8vo.

[11] ERSCH (J. S.) und GRUBER (J. G.), Allgemeine Encyclopädie der Wissenschaften, Leipzig, 1818 und folg. 4to.

The harvest to be gathered for the history of Acalephs from the works of anatomists of preceding periods would be so meagre that I have not even alluded to them thus far; though, with reference to some particular points of their structure, and especially those bearing upon their reproduction, it will be necessary hereafter to return to a consideration of the methods applied in their investigations by the great anatomists and physiologists of the eighteenth century, in order to trace the connection between the progress of our knowledge of the lower animals and the general progress of Zoölogy as a science. We owe to Cuvier the first anatomical description of a Medusa;[1] and next to this paper, those of Tilesius,[2] Eysenhardt,[3] Gäde,[4] Baer,[5] and Delle Chiaje,[6] deserve a special notice. Eschscholtz,[7] in his classical treatise on Acalephs, gives the first summary of the anatomy of these animals, and this is soon followed by Mertens's[8] investigations of the Beroids; Brandt's[9] descriptions of the Medusæ of Mertens, with numerous anatomical details; and the more special illustrations of Ehrenberg[10] on the organization of the Medusæ of the German Ocean; Milne-Edwards's[11] masterly observations on various Acalephs; Grant[12] on Beroe; R. Wagner[13] on the structure of Pelagia; Costa,[14] Hollard,[15] and Krohn[16]

[1] Cuvier (G.), Sur l'organisation de quelques Méduses, Bull. Soc. Philom. p. 69, Paris, 1800.

[2] Tilesius (W. G.), Beiträge zur Naturgeschichte der Medusen, N. Act. Nat. Cur. XV. 2, p. 247, fig., contains magnificent figures.

[3] Eysenhardt (C. W.), Zur Anatomie und Naturgeschichte der Quallen, N. Act. Nat. Cur. X. p. 375, fig., contains a very elaborate anatomy of the Rhizostoma Cuvieri.

[4] Gäde (Henr. M.), Beiträge zur Anatomie und Physiologie der Medusen, Berl. 1816, 8vo.

[5] Baer (Prof. K. E. v.), Ueber Medusa aurita, Meckel's Arch. VIII. p. 369.

[6] Delle Chiaje (St.), Memorie sulla Storia e Notomia degli Animali senza vertebre del Regno di Napoli, Nap. 1825–1830, 4 vols. 4to. fig. — Descrizione et Notomia degli Animali invertebrati della Sicilia citeriore, etc., Nap. 1841–1844, 6 vols. 4to.; 2 vols. fig.

[7] See note 1, p. 24.

[8] See note 3, p. 24.

[9] See note 4, p. 24.

[10] Ehrenberg (C. G.), Die Akalephen des rothen Meeres und der Organismus der Medusen der Ostsee, Ak. Wiss. Berlin, 1836, 4to. fig.

[11] Milne-Edwards (H.), Observations sur la structure de la Méduse marsupiale ou Charybdée marsupiale de Péron et LeSueur, Ann. Sc. Nat. 1833, vol. 28, p. 248, fig. — Observations sur la structure et les fonctions de quelques Zoophytes, Mollusques et Crustacés des Côtes de France, Ann. Sc. Nat. 2de sér. 1841, vol. 16, p. 193, fig. — Ann. Sc. Nat. 3e sér. 1857, vol. 7, p. 285. — Recherches Anatomiques et Zoologiques faites pendant un voyage sur les côtes de la Sicile, Paris, 1844, 4to. fig. vol. 1, p. 57. The last paper gives full descriptions of the gastrovascular system.

[12] Grant (R. E.), On the Nervous System of Beroe Pileus, Trans. Zool. Soc. I. p. 9, fig.

[13] Wagner (R.), Ueber den Bau der Pelagia noctiluca und die Organisation der Medusen, Leipzig, 1841, fol. fig.; also in Icones Zootomicæ, etc., Leipzig, 1841, fol.

[14] Costa (O. G.), Note sur l'appareil vasculaire de la Vélelle, Ann. Sc. Nat. 2de sér. 1841, vol. 16, p. 187, fig.

[15] Hollard (H.), Recherches sur l'organisation des Vélelles, Ann. Sc. Nat. 3e sér. 1845, vol. III.

[16] Krohn (A.), Ueber die Anwesenheit eigenthümlicher Luftkanäle bei Velella und Porpita, Arch. Naturg. 1848, vol. 1, p. 30.

on Velella; Philippi[1] on Physophora; Ecker and Leydig on Hydra;[2] Allman on Cordylophora;[3] Quatrefages on Physalia;[4] Huxley's Anatomy and Affinities of the Medusæ;[5] my own contributions to the natural history of the Acalephs of North America;[6] and the works and papers of Will,[7] Sars,[8] Forbes,[9] Leuckart,[10] Vogt,[11] Kölliker,[12] Gegenbauer,[13] and Schultze.[14] The papers relating more especially to the embryology of the Acalephs will be enumerated in the next section. General accounts of the structure of the Acalephs may be found in most text-books on Comparative Anatomy, especially in the more recent ones.[15]

[1] PHILIPPI (R. A.), Ueber den Bau der Physophoren und eine neue Art derselben; Müller's Arch. 1843, p. 58, fig.

[2] ECKER (AL.), Zur Lehre vom Bau und Leben der kontractilen Substanz der niedersten Thiere, Basel, 1848, 4to. fig. — LEYDIG (F.), Einige Bemerkungen über den Bau der Hydren, Müller's Arch. 1854, p. 270.

[3] ALLMAN (G. J.), On the Anatomy and Physiology of Cordylophora, Phil. Trans. Roy. Soc. 1853, vol. 143, p. 367.

[4] QUATREFAGES (A. DE), Mémoire sur l'organisation des Physales, Ann. Sc. Nat. 4e sér. 1854, vol. 2.

[5] HUXLEY (TH. H.), On the Anatomy and Affinities of the Family of the Medusæ, Phil. Trans. Roy. Soc. 1849, p. 413. — On the Anatomy of Physalia, Proc. Linn. Soc. 1848. — Observations upon the Anatomy of the Diphydæ, and the Unity of Organization of the Diphydæ and Physophoridæ, Proc. Linn. Soc. 1849. — Report on the Structure of the Acalephs; Brit. Assoc. for Adv. Sc. 1851. — Ueber die Sexual Organe der Diphyden und Physophoriden; Müller's Arch. 1851. — The Oceanic Hydrozoa; a Description of the Calycophoridæ and Physophoridæ observed during the Voyage of H. M. S. Rattlesnake; Ray Society, London, 1859, fol. fig.

[6] AGASSIZ (L.), Contributions to the Natural History of the Acalephæ of North America, Parts I. and II.; Amer. Acad. Arts and Sc. vol. IV. 1850.

[7] WILL (J. G. FR.), Horæ tergestinæ oder Beschreibung und Anatomie der Akalephen, Leipzig, 1844, 4to. fig.

[8] SARS (M.), Fauna littoralis Norvegiæ, Christiania, 1846 and 1856, fol. fig.

[9] FORBES (EDW.), Monograph of the British Naked-eyed Medusæ; Ray Society, London, 1847, fol. fig.

[10] LEUCKART (R.), Ueber den Bau der Physalien und Siphonophoren, Zeitsch. f. wiss. Zool. 1851, vol. 3. — Zoologische Untersuchungen, 1853, 4to. fig. — Zur nähern Kenntniss der Siphonophoren von Nizza, Arch. Naturg. 1854, I. p. 249. — Also FREY und LEUCKART, Beiträge zur Kenntniss wirbelloser Thiere, Braunschweig, 1847, 4to. fig.

[11] VOGT (C.), Ueber die Siphonophoren, Zeitsch. f. wiss. Zool. 1852, vol. 3, p. 522. — Untersuchungen über Thierstaaten, Frankfurt, 1851, 8vo. fig. — Recherches sur les animaux inférieurs de la Méditerrannée; Premier Mémoire, sur les Siphonophores de la mer de Nice, Genève, 1854, 4to. fig.

[12] KÖLLIKER (A.), Die Schwimmpolypen oder Siphonophoren von Messina, Leipzig, 1853, fol. fig.

[13] GEGENBAUER (C.), Beiträge zur nähern Kenntniss der Schwimmpolypen (Siphonophoren) Zeitsch. f. wiss. Zool. 1854, vol. 5, p. 285, and p. 442. Bemerkungen über die Randkörper der Medusen, Müller's Arch. 1856, p. 230. — Studien über Organisation und Systematik der Ctenophoren, Arch. Naturg. 1856, I. p. 163. — Versuch eines Systems der Medusen, mit Beschreibung neuer oder wenig gekannter Formen; Zeitsch. f. wiss. Zool. 1857, vol. 8, p. 202.

[14] SCHULTZE (MAX.), Ueber den Bau der Gallertscheibe bei den Medusen, Müller's Arch. 1856, p. 311.

[15] See notes to pages 26 and 27 of the first

SECTION V.

EMBRYOLOGICAL RESEARCHES UPON ACALEPHS.

The history of the successive steps which have led to a full knowledge of the reproduction and mode of development of the Medusæ exhibits some of the most interesting features in the annals of scientific discoveries, on account of the peculiarity of the facts brought to light in the course of the investigation not only, but also because the progress has been so very slow and gradual that it discloses, more clearly than most other subjects, the care, the patience, and the unrelenting perseverance, with which natural phenomena ought to be traced, in order to secure satisfactory results.

As I have already enumerated the numerous papers relating to the Embryology of Acalephs in another part of this work,[1] I shall limit myself here to a brief

volume of this work; to which may be added: COLDSTREAM (JOHN), Article Acalephæ in Todd's Cyclop. of Anat. and Phys. 1835, 8vo.; MILNE-EDWARDS Leçons sur la Physiologie et l'Anatomie comparée de l'homme et des animaux, Paris, 1857–1859, 4 vols. 8vo. — CARUS (V.), Icones Zootomicæ, mit Original-Beiträgen von Allman, Gegenbauer, Huxley, Kölliker, Müller, Schultze, Siebold, und Stein, Leipzig, 1857, fol.; and GEGENBAUER (C.), Grundzüge der vergleichenden Anatomie, Leipzig, 1859, 1 vol. 8vo.

[1] See vol. 1, p. 69. To the works there quoted may be added: HASSALL (A. H.), Catalogue of Irish Zoöphytes, Ann. and Mag. Nat. Hist. 1841, vol. 8. — STEENSTRUP (J. J. SM.), Untersuchungen über das Vorkommen des Hermaphroditismus in der Natur. aus dem Dänischen von Dr. C. F. Hornschuch. Greifswald, 1846, 4to. fig. — VAN BENEDEN (P. J.). Un mot sur le mode de reproduction des animaux inférieurs, Bulletins Acad. Roy. de Belgique. 1847. — REID (JOHN). Observations on the Development of the Medusæ, Ann. and Mag. Nat. Hist. 1848, vol. 1, p. 25. — GILES (EDW.) and CLARKE (W. B.). A few Remarks upon a Species of Zoöphyte discovered in the New Docks of Ipswich, Ann. and Mag. Nat. Hist. 1849, vol. 4, p. 26. — MÜLLER (J.), Archiv für Anat. und Phys. 1852, p. 32. (in the paper on the origin of shells in Holothuria.) — THOMPSON (W.), On the Analogy between the Processes of Reproduction in the Plant and in the Hydroid Zoöphyte, Ann. and Mag. Nat. Hist. 1854, XIV. p. 313. — BURMEISTER (H.), Zoonomische Briefe, Leipzig, 1856, 2 vols. 8vo. See vol. 1, p. 139. — PEACH (C. W.). Notice of a curious Metamorphosis in a Zoöphyte-like animal. Edinb. New Phil. Journ. 1856, vol. 4. — SARS (M.), Einige Worte über die Entwickelung der Medusen, Wiegmann's Archiv of Naturg. 1857. I. p. 117. — DALYELL (SIR JOHN G.), On the Propagation of Scottish Zoöphytes, Edinb. New Phil. Journ. 1834, vol. 17. and 1836, vol. 21. — GEGENBAUER (K.), Zur Lehre vom Generationswechsel und der Fortpflanzung bei Medusen und Polypen, Würzburg. 1854. 8vo. fig. — WRIGHT (J. J.). On the Reproduction of Cydippe pomiformis. Edinb. New Phil. Journ. 1856, vol. 4, p. 85. — Observations on British Zoöphytes, Edinb. New Phil. Journ. 1857–1859. — On Hydractinia echinata, 1857, Edinb. New Ph. Journ. — GOSSE (TH. H.), Naturalist's Rambles on the Devonshire Coast, Lon-

narrative of the successive steps which have furnished us with a connected account of the extraordinary modes of reproduction of this class of animals. The first facts relating to the history of the earlier stages of development of the most common Jelly-fish of the European seas, the Aurelia aurita, were observed by Sars, and related by him in a paper published in 1829,[1] and more fully illustrated in a subsequent work,[2] issued in 1835, which opens a new era in the natural history of the Acalephs. The fundamental discoveries made by Sars were afterwards generalized by Steenstrup, and presented to the world in a most unexpected connection with other genetic phenomena which had remained entirely unintelligible.

The first paper of Sars contains only descriptions of animals not noticed before;[3] but among them are those found in the sequel to represent the transitory stages in the growth of the common Medusa. These are here described as Scyphistoma and Strobila; the first being considered as a distinct genus of Polyps, the second as

don, 1853, 8vo. fig. — KROHN (A.), Ueber die Natur des kuppelförmigen Anhanges am Leibe von Phillirhoë bucephalum, Arch. Naturg. 1853, I. p. 278. — McCRADY (J.), Description of Oceania nutricula, and the Embryological History of a singular Medusan Larva found in the cavity of its Bell; Proc. Elliott Society, Charleston, S. C., 1857. — Gymnopthalmata of Charleston Harbor, Proc. Elliott Society, Charleston, S. C., 1858. — On the Development of two Species of Ctenophoræ found in Charleston Harbor, Proc. Elliott Society, Charleston, S. C., 1859. — ALLMAN (G. J.), On the Structure of the Reproductive Organs of certain Hydroid Polyps, Proc. Roy. Soc. Edinb. 1858. — Additional Observations on the Morphology of the Reproductive Organs in the Hydroid Polyps, Proc. Roy. Soc. Edinb. 1858. — SEMPER (C.), Ueber die Entwickelung der Eucharis multicornis, Zeitsch. f. wiss. Zool. 1858, vol. 9, p. 234, fig.

[1] The first paper of SARS appeared in 1829, under the title of Bidrag til Söedyrenes Naturhistorie af M. Sars, Cand. Theol. Förste-Haefte, med sex illuminerede Steentryktafler, 8vo. Bergen, 1829. At that time Sars was still "Candidatus Theologiæ." An abridged translation of this paper, with a reproduction of the plates, was published in Oken's Isis for 1833, p. 221. I myself have never seen the original, and I find that most writers have quoted the investigations related in this paper as bearing the date of 1833; but this is erroneous. The paper contained in the Isis of 1833 was not forwarded to Oken by Sars, but is simply a translation of the paper of 1829, with a few introductory remarks by Thienemann.

[2] SARS (M.), Beskrivelser og Jagttagelser over nogle mærkelige eller nye i Havet ved den Bergenske Kyst levende Dyr af Polypernes, Acalephernes, Radiaternes, Annelidernes og Molluskernes Classer, etc., Bergen, 1835, 4to. with 15 plates. I am indebted for a copy of this rare work to my friend Professor Eschricht of Copenhagen. As it may not be easily accessible to naturalists in this country, I would mention that abstracts of its contents may be found in the Isis of Oken for 1837, p. 354, in the Annales d'Anatomie, etc., II. p. 81, and in Wiegmann's Archiv fur Naturgeschichte, 1836, 2d vol. p. 197. What relates to Acalephs may be found p. 197–200.

[3] I avoid intentionally, whenever I can, the use of the expression *new*, as applied to animals not known before to naturalists; for, besides the impropriety of applying the word new to what has only been unnoticed before, I find that students of Palæontology are much puzzled in ascertaining whether that expression, when applied to fossils, means a newly discovered species, or one belonging to the more recent geological formations.

a peculiar genus of Acalephs, and both as distinct from all the other genera of Polyps and Medusæ known at that time. The genus Scyphistoma is considered as intermediate between Hydra and Coryne; *Scyphistoma filicorne*, the only species described, is characterized as having twenty-four to thirty-two tentacles, the mouth as being retractile and protractile, and the body as annulate. This last indication shows, that the Scyphistoma first observed by Sars was on the point of passing to the Strobila condition. The genus Strobila is thus described: Animalia nunc simplicia et libera, nunc plura invicem conjuncta, alterum scilicit super alterum positum, ita ut seriem forment, cujus extremitas infima pedunculo brevi est affixa, singulum animal disci formam referens, supra paullulum convexum, subtus concavum, margo disci in radios plures divisa. Os subtus maxime prominens tetragonum. One species, *Strobila octoradiata*: Margo disci in radios octo dichotomos divisa. When free, these discs are said to move like small Medusæ. The eight small ocelli between the lobes of the eight rays were correctly observed, and compared to those of the Medusa (Aurelia) aurita and Medusa (Cyanea) capillata. Thienemann, who furnished the abstract for the Isis, suggests that Sars should ascertain whether this is not the embryonic state of some Medusa. Sars himself considered Strobila as establishing a transition between the fixed Zoöphytes and the Medusæ, while Ehrenberg[1] mistook it for a Lucernaria in the process of transverse division.

In his later work, published in 1835, Sars gives a more detailed account of the Strobila, and shows that the animal he had described as a distinct genus under the name of Scyphistoma is simply an earlier stage in the development of the Strobila, and that the free discs of the Strobila are themselves closely allied to the animals described by Eschscholtz as Ephyra, a genus referred by the latter to the Acalephæ cryptocarpæ. This is illustrated by figures, on his Pl. 3d. These observations establish beyond the possibility of a doubt the fact, that extraordinary changes take place in animals that were at first considered to be Polyps, and the growth of which ends in the production of animals belonging unquestionably to the class of Medusæ. In a later note, Sars declares[2] that he has satisfied himself that the Ephyra-like Medusa arising from his Strobila is a younger state of the common Medusa (Aurelia) aurita, without, however, furnishing the evidence of this assertion, which is still questioned by Wiegmann.[3]

In 1841, Sars takes the whole matter up again, and in a masterly paper[4] demon-

[1] Ehrenberg (C. G.). Die Akalephen des rothen Meeres und der Organismus der Medusen der Ostsee, Berlin, 1836, p. 52.

[2] Wiegmann's Archiv für Naturgeschichte, 1837, vol. 1, p. 406.

[3] Wiegmann's Archiv für Naturgeschichte, 1837, vol. 2, p. 276.

[4] Sars (M.). Ueber die Entwickelung der Medusa aurita und der Cyanea capillata, Wiegmann's Archiv für Naturgeschichte, 1841, vol. 1, p. 9–34,

strates beyond the possibility of a doubt, that the Scyphistomas are the offspring of Medusæ; that they are transformed into Strobilæ, which produce Ephyroid Medusæ; and that the latter end their life as Medusa aurita and Cyanea capillata. All these facts are illustrated by beautiful figures. He begins by showing that the free disks of his Strobila are the young Medusa (Aurelia) aurita. He next instances facts showing the similarity of the development of Cyanea capillata with that of Aurelia aurita; *and then describes his attempts to raise the eggs of the Medusæ*, in which he succeeded so far as to show that Scyphistomas are developed from eggs laid by both these Medusæ, and thus closes the cycle of the investigation undertaken with the view of ascertaining the normal connection of all these animal forms. There can no longer be any doubt that they are genetically linked together, even though the transformation has not been watched through all its stages in one and the same specimen. The difficulty of keeping them alive for a sufficient time in confinement makes it impossible to obtain that kind of evidence. But as far as the closest similarity of the forms watched in confinement with those observed in their natural element is sufficient to trace their mutual dependence, the evidence is satisfactory and conclusive.[1]

The investigations of Sars had scarcely begun to be noticed in Germany when Siebold proceeded to trace the earliest stages of the formation of these animals.[2] His object was partly to revise the observations of Ehrenberg upon the structure of the Aurelia aurita, and partly to study the development of its eggs. To him we are indebted for the first accurate observations respecting the segmentation of the egg, and the formation of the embryo. Siebold clearly perceived the connection of the facts he had observed with those seen by Sars, yet a direct transition of the young from the state to which he had traced it to that observed by Sars was not seen by him.

The successive discoveries of Sars, combined with the investigations of von Siebold, had already led to a full knowledge of the characteristic features of the mode of development of the Medusæ, when Steenstrup took up this subject; and yet this ingenious observer gave a new impulse to the investigation of the Aca-

pl. 1–4. — *A French translation, by Dr. Young*, appeared in the Annales des Sciences naturelles, 2d series, 1841, vol. 16, p. 321.

[1] There are, however, two assertions in this paper with which I cannot coincide: 1st, the reversal of the young embryo when it becomes attached. Notwithstanding the objections of Sars, Siebold was right in what he said of the formation of the mouth, though he gave it up afterward. See note in *Wiegm. Arch. 1841, I. p. 20.* 2d, The base of the Strobila, after the Ephyræ are freed, does not die, as Sars states. Dalyell is correct when he affirms that they survive, and that tentacles reappear.

[2] SIEBOLD (C. TH. VON), Beiträge zur Naturgeschichte der wirbellosen Thiere; Neueste Schriften der naturforschenden Gesellschaft in Danzig, vol. 3d, No. 2, Danzig, 1839.

lephs, by the unexpected views under which he presented the facts recorded by his predecessors, so much so that a new era may be dated from the publication of his little work, for the history of the Acalephs not only, but also for the invertebrate animals in general. The whole aim of Steenstrup's investigations is fully expressed in the title of his work, "On the alternation of generations."[1] He expresses himself upon that point very clearly and in very few words, in his preface: "The substance of this paper is the fundamental idea expressed by alternation of generations. It is a remarkable, and, thus far, unexplained phenomenon of nature, that an animal brings forth a brood neither similar, nor growing to be similar, to the parent, but differing from it, and producing by itself another brood, that returns to the form and relations of the mother animal, in such a manner that a mother animal does not rear the like of itself, but reappears only in its descendants of the second or third or a following generation; and this appears always, in different animals, in a definite generation, and with definite intermediate generations."

Next to Sars and Steenstrup, Sir John Dalyell has been most successful in tracing the phenomena here alluded to. This author, whom Ed. Forbes, with his quick appreciation of every kind of merit in others, justly calls the Spallanzani of Scotland, has done more for the elucidation of the early history of the Medusæ than any other writer, although, from want of method in his descriptions and owing to his disregard of the modern systematic forms of presenting such subjects, his observations are only intelligible upon very careful perusal, and not available for a connected study of the gradual growth and successive phases of their development. For instance, it has not occurred to Sir John Dalyell, that what he calls "Hydra tuba" may be the offspring of several distinct genera of Medusæ, and so he con-

[1] STEENSTRUP (JOH. JAPETUS SM.), Ueber den Generationswechsel, oder die Fortpflanzung und Entwickelung durch abwechselnde Generationen, übersetzt von C. H. Lorenzen, Copenhagen, 1842, 8vo. fig. English translation by George Busk, published by the Ray Society: On the Alternation of Generations, London, 1845, 8vo. fig. Although the question of alternate generations is for the first time distinctly raised by Steenstrup, and presented by him as a phenomenon occurring not only among Radiates, but also among Mollusks and Articulates, it would be doing injustice to Sars not to remember, that, as far as the Medusæ are concerned, he had already correctly appreciated the character of the development of Aurelia aurita, which he does not consider as a simple metamorphosis of a larva, but as the metamorphosis of a new generation derived from the progeny of a Medusa. He goes even so far as to consider this mode of reproduction as a case parallel to that of Salpa, first observed by Chamisso, and to vindicate the accuracy of the investigations of the genial poet. Thus the groundwork upon which the theory of alternate generations could be reared is already laid out by Sars, when he says (Wiegmann's Archiv, 1841, vol. 1, p. 28), "It is, therefore, not the larva, or the individual hatched from the egg, that develops into a perfect Acaleph, but the brood arising from this larva by transverse division."

founded the history of at least two different genera; for I have no doubt, that, while the Hydra tuba, represented by him in his great work on "Rare and Remarkable Animals of Scotland," Vol. I., Pl. XIII., is the offspring of Aurelia aurita, the forms which he represents under the same name, Pl. XIV., are the offspring of Chrysaora, and those of Pl. XIX. are perhaps derived from Cyanea capillata.

In 1834, John Graham Dalyell[1] (afterwards Sir John) describes, under the name of Hydra tuba, an animal which is identical with Sars's Scyphistoma, already mentioned and figured by the latter in his paper of 1829; but Dalyell mentions many particulars, which seem to have for a long time remained unknown to other naturalists. He says that this animal is very voracious, and that it multiplies by budding, the buds remaining united to the base of the parent by a ligament, until this is ruptured as the embryo withdraws to establish itself independently. A single specimen had eighty-three descendants in thirteen months. Sars did not observe the budding before the year 1836,[2] and he did not see the buds separate and grow independently, as Dalyell did, and as I have done myself. In a subsequent paper,[3] Dalyell describes his further experiments with Hydra tuba up to 1836. He kept a colony of these animals alive, with their descendants, during six years, and numbers attained maturity. They fed rapaciously, grew and bred successive generations at all seasons of the year. In February and March he observed a pendulous flexible prolongation, of an inverted conical form, on the face or disk of some of these Hydras (the Strobila of Sars), developing gradually into twenty or thirty successive strata, broadening outwards, which, when more mature, were liberated, and swam at large in the water (the Ephyroid Medusa of Sars). He also considers them as Medusariæ, and gives good figures of one of them, figs. 2 and 3, p. 94. Later authors have failed to do justice to Sir John Dalyell. Speaking of his observations of the year 1836, Wiegmann, for instance, says,[4] that they contain so much that is enigmatical, that they require to be repeated and explained by other naturalists. Surely his own ignorance of the facts observed by Dalyell, the accuracy of which has been fully borne out, did not justify such a rebuke.

[1] On the Propagation of Scottish Zoöphytes, Edinb. New Philos. Journ. 1834, vol. 17, page 411, and Report British Association for Adv. of Science, 1834, p. 598. An abstract appeared in Froriep's Notizen. The name of Dalyell is misspelled in the Edinburgh New Philosophical Journal, and stands as Dalzell; under which name the author became known in Germany, and is quoted again and again in Wiegmann's Arch. for 1834, vol. 1, p. 303 and 305, and for 1837, vol. 2, p. 192.

[2] Wiegmann's Archiv, 1841, vol. 1, p. 24.

[3] Further Illustrations of the Propagation of Scottish Zoöphytes, Edinburgh New Philosophical Journal, 1836, vol. 21, p. 88; fully translated into German in Froriep's Notizen, vol. 50, No. 6, and in abstract in Wiegmann's Archiv, 1837, vol. 2, p. 278. The Isis of 1838 contains also abstracts of Dalyell's papers.

[4] Archiv, für Naturgeschichte 1837, 2d vol. p. 278.

Sars, again, speaks of them as partly confirmatory of his own, when, of course, the earlier observation was the original one, and the later ones should be considered as confirmations. The budding of the polypoid state of Strobila had been known to Dalyell for years before it had even been noticed by Sars. Dalyell already knew, in 1836, what Sars was still ignorant of in 1841, and, what seems hardly to be generally known even now, though it is certainly true, that the base of the Strobila resumes the form of the original Scyphistoma after the Strobila has dissolved itself into free Ephyræ.

But all these so-called "Hydra tuba" are not one and the same animal. They are the early stages of development of the different kinds of covered-eyed Medusæ which occur on the coast of Scotland, and the development of which presents similar phases. However, while Dalyell confounds in this manner the progeny of all the Steganophthalms of the vicinity of Edinburgh, his very mistake shows the more plainly how similar are the earlier stages of development of these different species of Medusæ.

It is much to be regretted, that the facts so carefully and patiently traced by Sir John Dalyell, for so many successive years, should not have earlier attracted the general attention of the investigators of Acalephs; for his work contains satisfactory information upon many points, which were afterwards discussed as if no observations had yet been made respecting them. Not less is it to be regretted, that Sir John Dalyell was not more fully acquainted with the investigations of Sars and of von Siebold. Had he known their import, his own results would have been much sooner incorporated into the history of these animals, while they would also have acquired more precision and directness in his own mind. As it happened, the highly important labors of Dalyell have remained almost unnoticed until recently, and have failed to exercise the influence they might have had upon the progress of science.

Various facts bearing upon the phenomena of alternate generations had been observed among Hydroids by Ehrenberg,[1] Loven,[2] Nordmann,[3] VanBeneden,[4] and

[1] Ehrenberg (C. G.), Die Korallenthiere des rothen Meeres physiologisch untersucht und systematisch verzeichnet, Berlin, 1834, 4to.

[2] Loven (S. L.), Beitrag zur Kenntniss der Gattung Campanularia und Syncoryne, Wiegmann's Arch. 1837, vol. 1, p. 249.

[3] Nordmann (Al. v.), Sur les changements que l'âge apporte dans la manière d'être des Campanulaires; Comptes-Rendus de l'Acad. des Sc. Paris, 1839, vol. 9, p. 704. This account is too short to be at all satisfactory.

[4] VanBeneden (P. F.), Mémoire sur les Campanulaires de la côte d'Ostende, considérées sous le rapport physiologique, embryogénique et zoologique; Ann. Sc. Nat. 2e sér. 1843, vol. 20, p. 350, et Mém. Ac. Brux. 1843, vol. 17, 4to. fig.—Mémoire sur l'embryogénie des Tubulaires, etc. Mém. Acad. Brux. 1844, 4to. fig.

Quatrefages,[1] without leading to conclusive results, when Dujardin turned his attention to the subject, and published two most important papers[2] describing the formation of genuine Medusæ from Hydroids; and thus establishing beyond question a genetic relation between animals of another family which had thus far been considered as belonging to different classes. Dujardin's investigations had a great influence in establishing the correctness of the views of Sars and Steenstrup, and in extending the range of our knowledge of the alternate generations; for, not only did he trace the development of several Medusæ from Hydroid Polyps, but he even saw the eggs of the free Medusæ derived from Hydroids reproduce their Hydroids. His second paper is accompanied by many beautiful figures, which add greatly to the clearness of his descriptions, and have forced the facts more directly upon the attention of naturalists.

Henceforward the study of the Acalephs is pursued in a new light and with broader views. The investigation of their affinities, their structure, and their mode of development, forms a part of their history; and their classification is modified accordingly, and gradually brought nearer and nearer to nature.

[1] QUATREFAGES (A. DE), Mémoire sur la Synhydre parasite (*Synhydra parasites*), nouveau genre de Polype voisin des Hydres; Ann. Sc. Nat. 2de sér. 1843, vol. 20, p. 230.

[2] DUJARDIN (FÉL.), Observations sur un nouveau genre de Médusaires (*Cladonema*) provenant de la métamorphose des Syncorynes; Ann. Sc. Nat. 2de sér. 1843, vol. 20, p. 370.—Mémoire sur le développement des Médusaires et des Polypes Hydraires; Ann. Sc. Nat. 3e sér. 1845, vol. 4, p. 257.

CHAPTER SECOND.

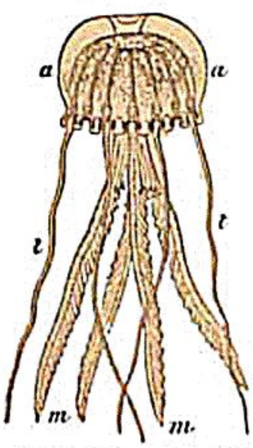
ACALEPHS AS A CLASS.

SECTION I.

MODE OF DETERMINING THE NATURAL LIMITS OF THE CLASS.

AFTER what has been said, in the first volume of this work, respecting systems in Zoölogy, it is hardly necessary to repeat here, that no arbitrary arrangement of animals can ever constitute a natural classification. Were it not so, every naturalist might present an arrangement suited to his individual views, and for which he would have as much authority as any one else. The absurdity of such a view, when clearly stated, is at once obvious. And yet most classifications have no better foundation for their details than a vague feeling of appropriateness in the minds of class of Acalephs, however, has presented particular difficulties to systematic writers; and it is not too much to say, that there are no two naturalists, conversant with the animals belonging to this type, who agree in their arrangement of them. Nay, the limits of this class are by no means clearly determined; for, while some unite under that name only the free moving gelatinous Radiata (*Fig.* 1), others would associate with them a number of pedunculated individuals and fixed communities of animals somewhat allied to Polyps (*Fig.* 2), and actually united with Polyps by some naturalists. Again, some refer to the class of Polyps all the compound

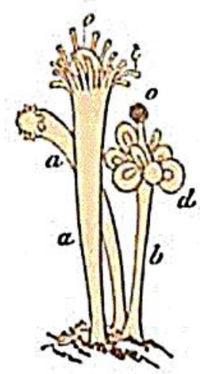
Fig. 1.



PELAGIA CYANELLA, Pér. and LeS.

a a Umbrella. — *m m* Mouth tentacles, or arms; the prolongation of the angles of the mouth. — *t t* Marginal tentacles.

Fig. 2.



HYDRACTINIA POLYCLINA, Ag.

a a Sterile individuals. — *b* Fertile individual, producing male Medusæ. — *d* Clusters of male Medusæ. — *o o* Proboscis, with the mouth at the apex. — *t* Elongated tentacles of the sterile individuals; in the fertile one *b*, they are simple knobs upon the proboscis *o*.

communities of free-moving gelatinous animals, the Siphonophoræ (*Fig.* 3), which others consider as genuine Acalephs, while some do not hesitate to unite all Acalephs and Polyps in one single division. On the other hand, we have lately seen a part of the Acalephs, the Ctenophoræ (*Figs.* 4, 5, 6, and 7), removed from that class, and referred to the type of Mollusks.

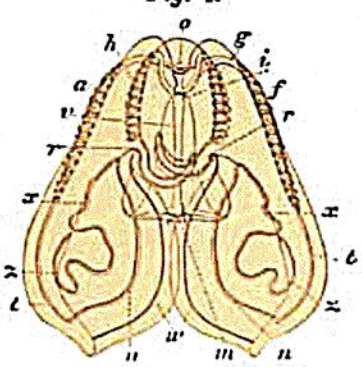
Fig. 8.

YOUNG PHYSOPHORA,
(*Copied from Gegenbauer.*)

e Buds of swimming bells.—*b b* So-called tentacles; lower *b* so called Polyp.—*c c* Feelers with lasso cells.—*r* Air sac.

Such conflicting views could not be entertained by so many and such eminent naturalists, did not almost insuperable difficulties obstruct our attempts to trace the truth. I know only one way to overcome these obstacles, and to attain greater precision on this subject. It is to test the affinities of all these animals by the standard of what is known of their mode of development, in the manner done before with full success for other classes; taking at the same time into account the homologies of their parts, as far as they can be ascertained. Embryology has, indeed, become

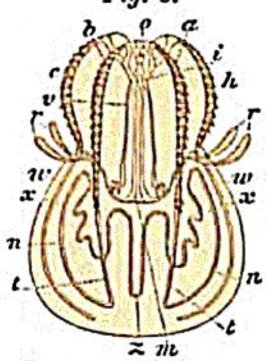
Fig. 4.



BOLINA ALATA, Ag.
(Seen from the broad side.)

a and *f* Long rows of locomotive fringes.—*g* and *h* Short rows of locomotive fringes.—*o* Central black speck (eye-speck?).—*i* to *m* Triangular digestive cavity.—*i* to *o* Funnel-like prolongation of the main cavity.—*v* Chymiferous tube of the tentacular apparatus.—*m* Tentacular apparatus on the side of the mouth.—*r r* Ear-like lobe, or auricles, in the prolongation of the short rows of locomotive fringes.—*t t* Prolongation of the vertical chymiferous tubes.—*n n* The same tubes turning upwards.—*x x* Bend of the same tubes.—*z z* Extremity of the same tubes meeting with those of the opposite side.—*w* Recurrent tube anastomozing with those of the auricles.

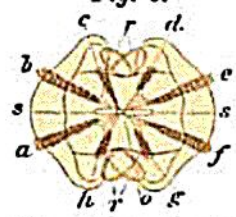
Fig. 5.



BOLINA ALATA, Ag.
(Seen from the narrow side.)

a b Long rows of locomotive fringes.—*c h* Short rows of locomotive fringes.—*o* Central black speck (eye speck?).—*i* Upper end of the digestive cavity.—*i* to *o* Funnel-like prolongation of the main cavity of the body.—*m* to *i* Digestive cavity.—*r r* Auricles.—*m* Mouth.—*t t* Prolongation of the vertical chymiferous tubes.—*n n* The same turning upwards.—*x x* Bend of the same tubes.—*z* Anastomosis of the two longitudinal tubes *t t*.—*w w* Recurrent tube, anastomozing with those of the auricles.—A comparison of this figure with *Fig.* 4 gives a distinct idea of the relative position of the digestive cavity *m* to *i*, and the chymiferous tubes of the tentacular apparatus *v*.

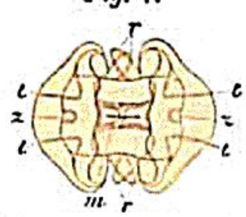
Fig. 6.



BOLINA ALATA, Ag.
(Seen from above.)

o Central black speck (eye speck?).—*a b e f* Long rows of locomotive fringes.—*c d g h* Short rows of locomotive fringes.—*r r* Auricles.—*s s* Circumscribed area of the upper end of the body.

Fig. 7.



BOLINA ALATA, Ag.
(Seen from below.)

m Mouth.—*r r* Auricles.—*t t t t* Prolongation of the vertical chymiferous tubes.—*z z* Anastomosis of these tubes.

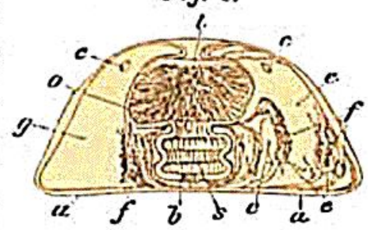
the key-note to the knowledge of the closer affinities among animals. Granting, for instance, that anatomy alone could have settled the question of the true affinities of the Barnacles with Crustaceans, I hardly believe, that, but for our knowledge of their embryology, naturalists would ever have dared to consider them merely as a group of the natural division of Entomostraca, which they really are. But for our knowledge of the mode of development of toads and frogs, their close affinity to Salamanders and to Ichthyoid-Batrachians could never have been determined with the same precision; but for our knowledge of the development of the Comatulæ, that family would for ever have remained associated with the Starfishes; and it seems to me that the inference is unavoidable, that the various modes of development of the Acalephs, as far as their embryology has already been traced, must afford the surest clue to the natural affinities of these animals, and, perhaps, furnish a standard also by which we may determine to what group certain polyp-like Radiata, alternately placed among Polyps and among Acalephs, truly belong. Should their special homologies coincide with the indications furnished by their embryology, all doubts on this point would seem to be removed; for, if the conclusions arrived at in those types of the animal kingdom which are now best known have any analogy with the phenomena observed in other types, we should be able to trace special homologies between all the representatives of the class of Acalephs, in the same manner as between all Insects, or between all Mammals.

In this way, it would scarcely seem difficult to determine whether those animals which have been at different times referred to the class of Acalephs and to that of Polyps truly belong to the one or the other, if the Polyps and Acalephs indeed constitute two classes, or if not, to demonstrate satisfactorily that they should form but one class. Again, all the representatives of the different classes of one branch are found to agree in their general homologies, as far as they have been thoroughly studied, — the Fishes with the Reptiles, Birds, and Mammals; the Insects with the Crustaceans and Worms; and the Acephala with the Gasteropods and Cephalopods. On the other hand, should there be any animals, thus far referred to the class of Acalephs or to that of Polyps, which do not agree in their general homologies with the true Polyps and the true Acalephs and Echinoderms, we should not hesitate to remove them from the type of Radiates. Thus we may also settle the question, whether the Ctenophoræ are true Radiates or Mollusks, as Quoy and Vogt have maintained.

In order to avoid any hasty conclusions, let us examine successively all the leading representatives of every group that may have been associated with either the Acalephs or the Polyps, both with reference to their homologies and their mode of development. Beginning with the Medusæ proper (Pl. III., IV., V., VI., VII., VIII., IX., XII., XIII., and XIV.), we find them to be animals which move freely, presenting an hemispheric gelatinous disk, in the centre of which a digestive sac is hollowed out. From the margin hang numerous filaments, and the central opening is surrounded by four larger appendages. From the central cavity arise many tubes radiating towards the periphery, where they anastomoze. The essential feature of this structure consists in the central cavity hollowed out of a continuous mass, which is traversed along its lower surface by radiating tubes. It requires but little familiarity with the Medusæ to know that the marginal fringes vary greatly in number, as well as in structure; some being hollow, while others are solid. These appendages are not even present in all Medusæ; for neither the Rhizostomata nor the Cassiopeiæ nor the Cepheæ have them. The central opening presents also marked differences in its outward termination. In some it has a simple rim, while in others, four or more prominent angles may extend outward and assume the shape of very complicated appendages. But in no Medusa is the margin of the central opening inverted into the digestive cavity.

Not so with the Actiniæ (*Fig.* 8) and the other Actinoid Polyps. Here the walls of the body, whether soft, or hardened by calcareous deposits, enclose a wide cavity, which is divided by radiating partitions into a number of chambers, communicating freely with the so-called tentacles or marginal fringes. The central opening does not communicate directly with the main cavity of the body, but leads into a distinct digestive sac, suspended in the main cavity. It is as if the upper part of the hollow cylindrical body had been turned into the cavity below, its edge hanging free and open in that cavity, though capable of closing by contraction. We have here, then, two distinct types; but they are homologous in all their parts. The outer wall of the Actiniæ corresponds to the gelatinous disk of the Medusæ, only that the centre of its outer surface is so constructed as to enable these animals to attach themselves by it, while in the Medusæ it is uniformly rounded off, and affords no point of attachment. The marginal fringes of the Actiniæ correspond to the marginal fringes of the Medusæ, only that in the Medusæ they communicate directly with the marginal circular tube, and through this with the radiating tubes, while in Actiniæ they open directly into the radiating chambers. The radiating tubes of the Medusæ correspond, it is true, to the radiating chambers of the Actiniæ; but in Actiniæ these chambers open freely for their whole length into the centre of the main cavity of the body, while in the Medusæ the radiating tubes are closed cylinders, opening only at their inner end into the main cavity. The central opening leads, in both, into the main cavity of the body; but in Medusæ the margin of that opening is turned outward, and may be prolonged into large appendages, between the inner surfaces of which a cavity is formed leading into the main cavity, while in the Actiniæ the outer margin of the central opening is turned inward and extends to a considerable length into the main cavity, so that the inner surface of the sac so formed corresponds to the outer surface of the wall of the main cavity; and it is

Fig. 8.



ACTINIA MARGINATA, LeSueur. (Contracted and the tentacles drawn in.)

a a Base of the animal. — *b* Opening of the digestive sac leading into the main cavity of the body. — *c c* Opening leading from one radiating partition into the other. This opening is homologous to the circular chymiferous tube of the naked-eyed Medusæ. — *e e e* Radiating partitions. — *f f* Bunches of eggs hanging from the inner margin of the radiating partitions. — *g* One of the largest radiating partitions, to which the digestive sac is attached. — *o* Tentacles. — *s* Digestive sac.

this body wall, and not the mouth, which is surrounded by radiating appendages outside of the central opening.

This comparison is in itself sufficient to show, that, while every part in a Medusa is homologous to every part in an Actinia, these homologies are only general homologies; that is, indications that these two animals belong to the same branch of the animal kingdom, but that special homologies cannot be traced between them. The body of the Actinia has a flat disk at the lower end, which, though contiguous with the outer wall, differs from it so much as to constitute a base of attachment entirely wanting in the Medusa. The upper part of the lateral walls of the Actinia is thinned in a manner which forms a sort of circular neck below the fringes, facilitating the inversion of the whole margin towards the centre in a manner impossible to the Medusa. The central opening of the Actinia is not circumscribed by the margin of the upper part of the walls of the body, but that margin is turned inward; while in the Medusa it hangs free, outward. The radiating hollow spaces are limited in Actinia by radiating partitions, the inner margin of which is free, and suspended vertically in the main cavity; while in the Medusa, what may be compared to the partitions of the Actinia is a continuous gelatinous mass, between which simple tubes are left, communicating only through narrow openings with the central cavity, or in other words, the homologous parts of the Actinia and Medusa exhibit a structure special to each.

We find the same special homologies in all the Actinoid Polyps. They all have a cylindrical body with a central cavity, divided into chambers by radiating partitions, marginal fringes communicating with these chambers, and a digestive cavity hanging free into that cavity below the central opening; while in all Medusæ we find the same continuous gelatinous body with a simple central cavity and radiating tubes, and a margin of the central opening turned outward. Now, if the classes of each branch of the animal kingdom, as has been shown in the first volume of this work, are natural divisions exhibiting the same plan of structure, but built respectively in different ways and with different means, we have, in Actinia and in Medusa, the types of two distinct classes; and it only remains for us to examine what are the natural limits of these classes, and what different kinds of animals belong to each. I hold, however, that the preceding remarks are in themselves sufficient to show that it is an exaggeration of their affinities to unite, as Leuckart has done, and as most German naturalists now do, the Polyps and Acalephs in one and the same great division under the name of Cœlenterata.[1]

[1] LEUCKART (R.), Ueber die Morphologie, und die Verwandtschafts-Verhältnisse der wirbellosen Thiere, Braunschweig, 1848, 8vo. p. 13. Full of original investigations and suggestions.

SECTION II.

THE DIFFERENT ANIMALS REFERRED TO THE TYPE OF RADIATA.

I shall presently show that all the true Polyps and all the true Acalephs may naturally be grouped with the two characteristic representatives of their respective classes, alluded to in the preceding section; and that, in connection with the Echinoderms, they constitute one of the four great types of the animal kingdom, characterized by a peculiar plan of their structure, founded upon the idea of radiation; and that the anatomical differences exhibited by the Echinoderms do not justify us in considering them as a distinct type.[1] The latter are, in reality, only another class of Radiata, as a comparison of any of the flat Echinoids, such as the Echinarrachnius, with an ordinary Medusa, say the Aurelia, readily shows; Echinus being, as it were, a Medusa, the soft disk of which is charged with limestone particles. But before proceeding to demonstrate these propositions, it is proper to take a glance singly at all the different beings which, at different times, have been associated with or removed from the Radiata.

Whether considered as a distinct type, or simply as a class of the Radiata, the Echinoderms, as a natural group, are now very generally circumscribed within the same limits by all naturalists. The question, long agitated among zoölogists, whether the Sipunculoids should be associated with the true Echinoderms or referred to the class of Worms, has finally been settled in favor of their complete removal, by the investigations of the late lamented J. Müller.[2] We may henceforth consider as Echinoderms all the radiated animals provided with an ambulacral system, and need not for the present enter into a farther consideration of their structure and general affinities, but leave them out of consideration until we attempt to trace the general homologies, which, in connection with their mode of development, bind these animals indissolubly with the Acalephs and Polyps as a separate class of the type of Radiata.

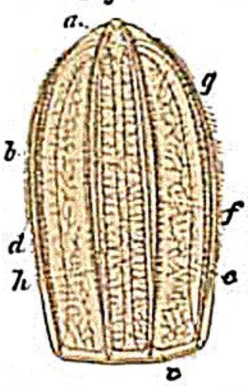
The natural limits of the class of Acalephs cannot be considered as settled,

[1] The separation of the Echinoderms from the other Radiates, as a distinct type, was first proposed by Leuckart in the work quoted on the preceding page. This distinction has been adopted by Kölliker, and by Gegenbauer in his recent excellent text-book of Comparative Anatomy. To me, however, such a division of the Radiates into two types seems unjustifiable, since the consideration of the complication of their structure is surely a feature subordinate to the idea of their plan of structure; and the mode of execution of a plan should not be confounded with the plan itself.

[2] Ueber den Bau der Echinodermen, Ak. d. Wiss. Berlin, 1854.

since Quoy[1] and Vogt[2] would remove the Beroids not only from that class, but even from the type of Radiata, and refer them to the lower Mollusks in the vicinity of the Ascidians. It seems hardly credible, that the author of an extensive and highly valuable monograph upon the swimming Ascidians[3] should entertain such an opinion. Every idea of typical plans of structure, as a guide in the general classification of the animal kingdom, must be given up by those who would associate animals that are so distinctly radiated as the Ctenophoræ with others in which the bilateral type is so evident as in the Tunicata, and place them in an intermediate position between the latter and the Bryozoa. A general comparison will be sufficient to show that the Ctenophoræ or Beroid Medusæ are truly Radiata. This may best be seen in our Idyia (*Fig.* 9), where the central mouth, surrounded by a circular tube, leads into a vast digestive cavity, above which arise two horizontal tubes, each dividing into four branches. These branches follow the surface of the cylindrical, slightly compressed walls of the animal, and unite again with the circular tube encircling the mouth. On the outer surface of the body extend eight vertical rows of flappers, whose upper ends converge to a central knob at the summit of the animal. The rows of flappers, the hollow tubes, the central mouth, the rosette at the summit, every essential feature in the structure of these animals, is as strictly radiated as in any other Radiata in which indications of a bilateral arrangement are subordinate to the general plan of radiation. These subordinate features in the genus Idyia consist of two additional radiating tubes along the sides of the animal, in the flattening of the digestive cavity which exists also in all the Polyps, and in the eccentric position of the double anus. This eccentricity of the terminal end of the alimentary canal occurs, however, in the majority of Echinoderms, as well as in the Ctenophoræ, only that in Echinoderms the anus is simple. But the Ctenophoræ are not only radiated; they, in fact, are radiated after the fashion of the other Acalephs, and ought to remain associated with the common Medusæ, as they have been ever since Cuvier distinguished these animals as a class.

Fig. 9.



IDYIA ROSEOLA, Ag.
a Anal opening.—*b* Lateral radiating tube.—*c* Circular tube.—*d e f h* Vertical rows of locomotive fringes.—*g* The locomotive fringes seen in profile.

The special homologies of the Ctenophoræ and true Medusæ are most striking. A comparison with Aurelia will at once show this. From the main cavity arise,

[1] QUOY et GAIMARD, Voyage de l'Astrolabe, Zoologie, vol. 4, p. 36.

[2] VOGT (C.), Zoologische Briefe, Frankfurt a. M., 1851, vol. 1, p. 254.

[3] VOGT (C.), Recherches sur les animaux inférieurs de la Méditerranée; 2d. Mémoire, sur les Tuniciers nageants de la mer de Nice, Mém. de l'Institut national genevois, Genève, 1854, vol. 2.

in opposite directions, two main stems of the chymiferous tubes. Each of these divides into two forks, which in their turn are subdivided again, so that each stem ends in four branches opening into four vertical tubes, extending without farther ramifications to the lower margin of the animal; and all this with only such differences in the number of branches as occur between different genera among genuine Medusæ. We have even in Idyia, in the two simple tubes that follow the flattened sides, a close resemblance to the arrangement prevailing in Aurelia, where straight, simple tubes alternate with those that are subdivided.

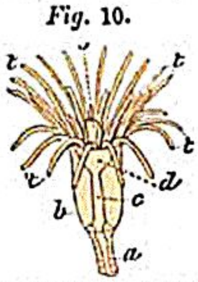
These facts may be sufficient to show that the Ctenophoræ cannot be separated from the ordinary bell-shaped Medusæ; yet when we come to examine the characteristics of the orders in the class of Acalephs, we shall trace those homologies farther, and also show how the structure of all the Ctenophoræ, even of those differing most from the type of Idyia, such as Cestum, Lesueuria, Bolina, and Pleurobrachia, is strictly homologous to that of Idyia in all their peculiarities.

Among the Discophoræ there exists also a great diversity; and I shall compare closely all their different types, when examining the natural limits of that order. Suffice it to say here, that the Rhizostomes, which have been represented as widely differing from the others in the structure of their mouth, differ only in so far that the edges of the four pendent branches of the central peduncle — which are free for their whole length in Aurelia, Chrysaora, Pelagia, and Cyanea, and form four channels leading to a central opening, the so-called mouth, that opens into the main cavity — are soldered together for their whole length in Rhizostoma, Cephea, and Cassiopeia, leaving only here and there small openings between their folds, through which a less bulky food passes in the same way as in the common Medusæ, along the channels thus formed, into the main cavity of the body. The homology is perfect, the only difference being that the edges of these four appendages coalesce, instead of remaining open. (See Pl. XIII. and XIV.)

Before the mode of reproduction of the so called naked-eyed Medusæ was known as it now is, no question could be raised as to their affinity; and they were simply referred to the order of Discophoræ. But since many of them have been ascertained to arise from buds formed upon the stem, or between the tentacles, of the crown of the so-called Hydroid Polyps, the question now is, whether their association with the ordinary Discophoræ in one and the same order is true to nature or not; and further, what should be the position in a natural system of the Hydroids themselves, which, before these discoveries, were unhesitatingly associated with the ordinary Polyps. Does this show that genuine Polyps produce genuine Medusæ, to be considered as distinct animals; or that the Hydroids, with their respective Medusæ, are only alternate modes of existence of the same being? Or does it follow from these facts, that the classes of Polyps and Medusæ must be united into one? That there is a considerable difference between the Medusæ arising as buds from Hydroids and the other Discophoræ appears plainly from the fact, that Eschscholtz has already separated them into two groups, calling the former Discophoræ Cryptocarpæ, and the latter Discophoræ Phanerocarpæ; while Forbes, grouping them in a similar manner, calls the former Gymnophthalmata and the latter Steganophthalmata, and Gegenbauer, Craspedota and Acraspeda. This distinction, it is true, is mainly founded upon differences in the structure of the ovaries and spermaries, of the eye-specks of the margin of the disc, and of the radiating tubes, which are much fewer in the naked-eyed Medusæ, and generally simple; but now the striking peculiarity of their mode of reproduction may be added to separate them with more precision.

It is important here to remark, that the so-called Hydro-Medusæ have generative organs only in their Medusa state, and that the Hydroids themselves show no sign of sexuality; for I shall show hereafter that what has been considered as sexual organs in some Hydroids are themselves Medusæ, differing simply from the ordinary naked-eyed Medusæ in not separating from the Hydroid stem upon which they bud. The Hydroids appear, then, as a kind of larval condition of the Hydro-Medusæ; and, in my opinion, can no more be considered as genuine Polyps, than the wormlike larvæ of Insects can be considered as genuine Worms. For, just as by a series of transformations the worm-like young of the Insect pass into the state of perfect Insects, so also are the Hydroids a state of the naked-eyed Medusæ preceding the maturity of the latter, and standing in a definite relation to them, even though that relation be not exactly the same as that which exists between the Insect larva and the perfect Insect. The Hydroids are no more a distinct group of animals than the larvæ of Insects, and while they bear a certain resemblance to Polyps, they can no more be united with the Polyps than the larvæ of Insects with the Worms, except in as far as they belong to the same branch; for the Worms, as a class, stand in the same relation to the Crustacea and Insects as the Polyps to the Acalephs and Echinoderms. The structural peculiarities that essentially distinguish the Insects from the Worms appear already in their larvæ, which are provided with tracheæ as well as the perfect Insects. And so also is the structure of the Hydroids a Medusa structure (*Fig.* 10), and not a Polyp structure. The margin of the mouth spreads outward, and is not inverted to form a digestive cavity distinct from the main cavity of the body. Moreover, the main cavity of the body in the Hydroid has no radiating partitions, as that of the Polyps has; and this is true of all Hydroids without exception. Those from which the Medusæ

Fig. 10.

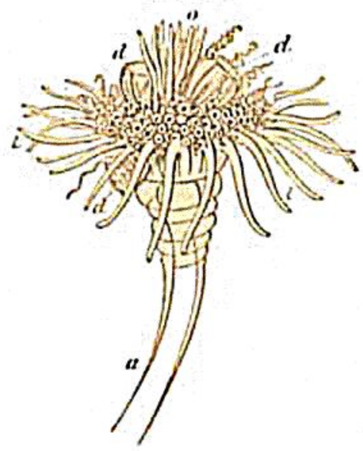


CAMPANULARIA, expanded.
a Axis of the body.—*b* Calyx.—*c* and *d* Digestive cavity.—*o* Mouth.—*t t t* Tentacles.

buds are not freed have no more the special structure of the Polyps described above, than those which produce free Medusæ.

Whether we consider their special structure or their genetic relation to certain Medusæ, the Hydroids must be associated in close connection with the Medusæ proper; while their peculiar mode of reproduction, and the greater simplicity of their structure when compared to that of the covered-eyed Medusæ, show that they form a distinct group in that class. This will be still more evident, should I succeed in showing that all Hydroids produce, in the same way, Medusæ buds; even though these Medusæ do not in all of them separate from the mother stem to lead an independent life. The family of Tubulariæ is most interesting in that respect, because, while they all agree in their Hydroid state, there are some, among them the genus Hybocodon (*Fig.* 11), for instance, in which the buds (*Fig.* 11 *d d*, and *Fig.* 12), though at first not differing from those of other kinds, become free and lead an independent life as distinct, sexual, naked-eyed Medusæ (*Figs.* 13, 14). In others, such as Tubularia proper, Thamnocnidia, and Parypha, the

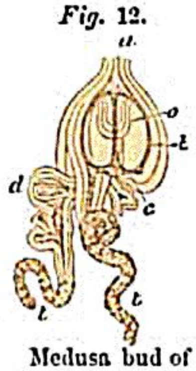
Fig. 11.



HYBOCODON PROLIFER, Ag.

a Stem of a single Hydra. — *o* Its mouth surrounded with tentacles. — *t t* Its marginal tentacles. — *d d d* The most advanced of its Medusæ buds.

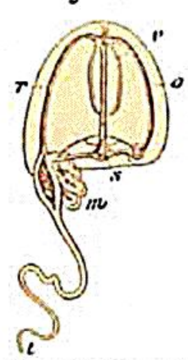
Fig. 12.



Medusa bud of
HYBOCODON PROLIFER, Ag.

a Base of attachment to the Hydra stock. — *o* Proboscis. — *c* Circular chymiferous tube. — *b* Radiating chymiferous tube. — *d t* Proliferous Medusa with its single tentacle. — *t* Single tentacle of the primary Medusa. — Near *c* Another small proliferous Medusa-bud, and several others upon the main radiating tube of the proliferous Medusa *d t*, between the letters *d* and *t*; exhibiting a striking analogy to Siphonophoræ.

Fig. 13.



Free Medusa of
HYBOCODON PROLIFER, Ag.

The largest vertical tube being seen in profile. At first sight this Medusa resembles much the Steenstruppia of Forbes; yet it differs generically.

v Proboscis. — *r o* Radiating tubes. — *s* Circular tube. — *t* Tentacle. — *m* Buds of Medusæ, proliferous from the base of the single tentacle.

Fig. 14.

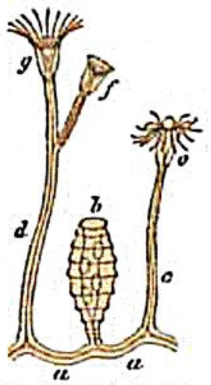
Free Medusa of
HYBOCODON PROLIFER, Ag.

Facing the largest chymiferous tube, from the lower end of which hangs the single tentacle, with many small proliferous Medusæ buds.

a Point of attachment before its separation from the Hydra stock. — *b c* Radiating or vertical chymiferous tubes, *c* pointing to the circular tube. — *t* Tentacle. — *f* Bunch of proliferous Medusæ buds. — *e* Rows of epithelial cells forming distinct bands at the surface. — *o* Proboscis.

Medusæ buds produce new Hydroids without freeing themselves; and yet these Medusæ buds show all the characteristic features of genuine naked-eyed Medusæ. In Tubularia proper, for instance (Vol. 4, Pl. XXIV. and XXVI., figs. 3 and 4), they have four radiating tubes with a pendent proboscis and a circular tube, but hardly a trace of tentacles; while in other genera these characters are variously combined. Thamnocnidia (Vol. 4, Pl. XXII.) has four distinct tentacles and a large proboscis, but neither radiating nor circular tubes. Parypha (Vol. 4, Pl. XXIII.) also has tentacles, but of a very different form, and a large proboscis, but no chymiferous tubes.

Fig. 15.

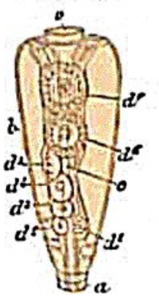


TROCHOPYXIS, Ag.
New genus of Campanulariæ.

aa Common basis of the community. — *b* Fertile Hydra. — *c d* Stems of sterile Hydræ. — *e g* Sterile Hydræ expanded. — *f* Secondary sterile Hydra bud.

In the family of Campanulariæ, the Hydroids seem to differ greatly from the Tubulariæ, the stem being horny, and the bell-shaped animal surrounded by a horny bell; but a microscopic examination of the surface of the stem, and even of the bell, of all Hydroids, shows that the only difference in the outer layer of the animal consists in the thickness of that hyaline layer which in Campanularia and Sertularia becomes so firm as to assume permanent forms and to be visible to the naked eye as a sort of horny sheath enclosing all the soft parts, while in Tubularia it is soft and flexible. This once understood, the difference between a Campanularia (*Fig.* 15) and a Tubularia head is only such as we should expect between members of different families, — they differ in form only. Yet there is another distinction to be made among them. The individuals of the same community, united upon the same stem but arising from different axes, exhibit marked differences among themselves: the larger number, which have all the same form, remain for ever sterile (*Fig.* 15, *c d*), while others, of a different form, produce buds along their internal proboscis (*Fig.* 16 d^1, d^2, d^3, d^4, d^5, d^6, d^7), which in due time free themselves and swim off as distinct Medusæ (*Fig.* 17). This is, for instance, the case with Thaumantias and Tiaropsis, which are only the free Medusæ of different genera of Campanularians. The same is the case, again, with the Sertularians (*Fig.* 18), which produce other kinds of free Medusæ.

Fig. 16.



FERTILE HYDRA of Campanularia.

a Base of attachment. — *b* Calyx. — *c* Digestive tube. — *o* Mouth. — d^1 d^2 d^3 d^4 d^5 d^6 d^7 Medusæ buds successively older. I have frequently seen these buds freeing themselves and assuming the form of *Fig.* 17.

Fig. 17.

FREE MEDUSA of the Campanularia represented in *Fig.* 16. It is represented here with the margin of the disc and the tentacles raised, while the proboscis is pendent. Its adult state is described in the Contributions to the Nat. Hist. of the Acalephs, under the name of Thaumantias.

c Mouth and proboscis. — *o o* Radiating chymiferous tubes. — *e e* Eyes. — *t t* Tentacles.

Fig. 18.

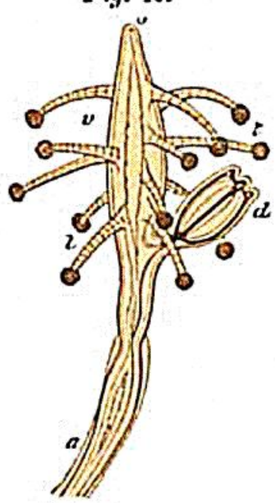
DYNAMENA FABRICII, Ag.
One of the most common Sertularian Hydroids of our coast.

a b c Single individuals; that occupying the cell *b* is entirely, and that in cell *c* partly, expanded.

With these facts before us, there can be no doubt left in the mind of any unprejudiced observer, that, even though the Hydroids from which arise many of the naked-eyed Medusæ thus far described have not yet been ascertained, and though many Hydroids are known the Medusæ of which have not yet been identified, enough is clearly understood of the relations of Hydroids and naked-eyed Medusæ to show that there is a genetic connection between them all, and such an identity in the essential structure of the Hydroids on one side and the naked-eyed Medusæ on the other, that the view which represents the Hydroids as true Polyps must be for ever banished from our science. This would be none the less true even should it appear that the genuine Polyps form part of a larger division, embracing also the Hydroids with the naked-eyed Medusæ; for such a comprehensive division would still have to be subdivided into secondary groups, no one of which could include at the same time true Polyps and Hydroids, without conflicting with their natural affinities.

A few more words upon the Sertularians and Campanularians and their free Medusæ will set this matter at rest. A sterile head of Campanularia (*Fig.* 10, and 15 *c d*), which is so strictly homologous to Sertularia or Dynamena (*Fig.* 18) that a comparison between the two is superfluous, shows a bell-shaped body, in every respect identical with that of a Tubularia or Hybocodon (*Fig.* 11). It has a row of feelers around its margin like the latter, only the feelers are more active, and capable of being drawn in more completely. The floor stretched across the wider part of the bell is open in the centre, where we find the oral aperture. The only difference in these parts between Campanularia and Tubularia is, that the centre of this floor rises, in Tubularia, in the shape of a proboscis, while in Campanularia it may only be raised to a small extent, but is at the same time capable

Fig. 19.

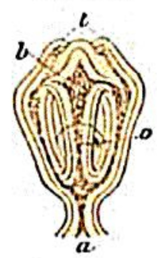


CORYNE MIRABILIS, Ag.

Hydra with a Medusa bud. The buds when freed become Sarsiæ. See fig. 21.

a Stem of the Hydra. — *v* Its club-shaped body. — *o* Its mouth. — *t t* Tentacles scattered over the body. — *d* Medusa bud.

Fig. 20.

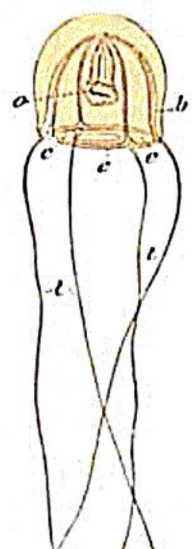


Medusa bud of CORYNE MIRABILIS, Ag.

The bud represented here separately, with its base of attachment *a* cut through, is younger than that represented in its natural connection in fig. 19 *d*. The free Medusa is represented *Fig.* 21, and described as *Sarsia mirabilis* in the Contributions to the Nat. Hist. of the Acalephs.

a Base of attachment to the Hydra stock. — *o* Proboscis. — *b* Radiating chymiferous tubes. — *t* Tentacles.

Fig. 21.



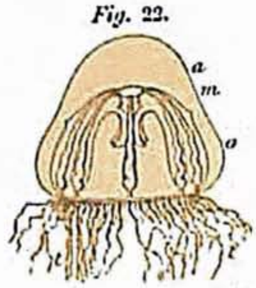
The free Medusa, SARSIA, of CORYNE MIRABILIS, Ag.

o Proboscis. — *b* Vertical chymiferous tube. — *c* Circular tube. — *e e* Diaphragm. — *t t* Tentacles.

of greater expansion and contraction. There is in that respect no greater difference between Campanularia and Tubularia as Hydroids, than between Sarsia (*Figs.* 19 *d*, 20, and 21) or Hybocodon (*Figs.* 12, 13, and 14) as naked-eyed Medusæ and

Thaumantias (*Fig.* 17) or Melicertum (*Figs.* 22, and 23), which are respectively the free Medusæ of a Coryne (*Fig.* 19), a Tubularian (*Fig.* 11), a Campanularian (*Figs.* 10 and 16), and a Sertularian (*Fig.* 18). And if we compare the Coryne with the Tubularia, the only essential difference we notice is, that while in Tubularia the feelers are arranged in a whorl around the base of the proboscis, in Coryna they are scattered all over the proboscis.

Fig. 22.

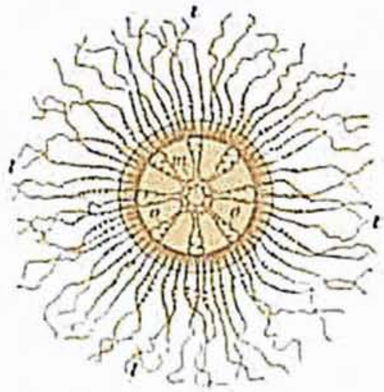


MEDUSA CAMPANULA, Fabr. (A species of Melicertum *Oken*, seen in profile.)

The free Medusa of a very common Sertularian Hydroid of the North American coast.

t Tentacles. — *o* Ovaries, along the vertical chymiferous tubes. — *m* Mouth. — *a* Disc.

Fig. 23.



MEDUSA CAMPANULA, Fabr. (A species of Melicertum *Oken*, seen from above.)

The free Medusa of a very common Sertularian Hydroid of the Atlantic coast of North America.

m Mouth. — *o o* Ovaries along the vertical chymiferous tubes. — *t t t* Tentacles.

There is only one more group of animals that has been associated with the Medusæ. I mean the *Acalèphes hydrostatiques* of Cuvier, called *Siphonophoræ* by Eschscholtz and the more recent writers. From the time they became first known through the descriptions of Forskål and the splendid illustrations of LeSueur, they have always been considered as allied to the Medusæ, until recently Kölliker has associated them with the Polyps under the name of swimming Polyps, *Polypi Nechalei.* An opinion expressed without hesitation by so eminent an investigator as Kölliker requires the most careful examination. To arrive at a satisfactory result on this critical point, it is necessary, in the first place, to consider the fact, that the so called swimming Polyps, the Siphonophoræ of most authors, are compound animals, — that is to say, communities of individuals organically connected in a manner similar to the community that exists between the numerous individuals of a Coral stock or of a Hydroid stock. But this is not all. The individuals so connected in these communities have no more the same appearance than those of the communities formed by certain Hydroids; and that we may be the better prepared to appreciate the extraordinary extent to which different individuals of the same community may differ in a stock of so called swimming Polyps, it may be well to consider beforehand the extent of the differences we observe between the individuals of similar stocks among genuine Polyps, as well as among Hydroids.

In a Polyp community the rule is, that all the individuals of the same stock resemble one another in every respect, differing slightly in size, and, it may be, as in the confluent species, in the number of mouths, circumscribed by a continuous series of tentacles, as for instance in Mæandrina, Diploria, Gyrophyllia, Manicina, etc. In some of the Madrepores, however, and especially in those which produce numerous distinct branches, there is a greater difference, each branch terminating with a larger Polyp, which is perfectly symmetrical; while the individuals which stand upon the sides of the branches are not only smaller but at the same time one-sided, the broader and more prominent side being turned outward, and the tentacles on that side being also larger than those turned toward the common axis.

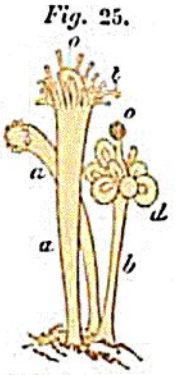
Among the Hydroids, as among the Polyps, we find those in which the communities are formed by identical individuals differing, perhaps slightly, in size. This is the case in the families to which the genera Tubularia (Vol. IV., Pl. XXIV.) and Coryne (Pl. XVII., XVIII., and XIX.) belong. But there are others, in which we find, either constantly or at least at certain seasons, two kinds of individuals, differing not only in size, but also in form, and still farther in the presence or absence of tentacles, one kind being always sterile, while the other produces Medusæ buds that may be freed. This is the case with the Campanularians (*Figs.* 10, 15, 16, and 17) and the Sertularians (*Figs.* 18, 22, and 23). In the Plumularians, the differences are still more marked; for besides the fertile individuals there are several kinds of sterile individuals, grouped together in various clusters, the smaller ones being attached around the large ones. Finally, there is a genus—Hydractinia (*Figs.* 24 and 25)—which, among the Hydroids, exhibits the greatest range of difference thus far observed between the individuals of the same species. For in this genus we have, in the first place, two kinds of communities: one (*Fig.* 25) in which the fertile individuals produce only male Medusæ, and another (*Fig.* 24) in which the fertile individuals produce only female Medusæ. Again, the fertile individuals in both kinds of communities have tentacles (*Figs.* 24 *o* and 25 *b*, *o*) entirely different from those of the sterile individuals. The sterile individuals (*Figs.* 24 *a* and 25 *a*) differ also greatly among themselves, some being slender and almost thread-like; others slender, but with a distinct proboscis and a whorl of tentacles; others short, widening greatly upward, and assuming almost the form of a trumpet-mouth. All these individuals differ not only in their form and complication, but also in their color, so that we have in this genus about as great a diversity of individuals in one community, as is observed in the most complicated Siphonophoræ. The only difference between the two groups consists in this: that while all

Fig. 24.

HYDRACTINIA POLYCLINA, Ag.

a Sterile individual.—*b* Fertile individual producing female Medusæ.—*d e* Female Medusæ containing advanced eggs.—*f g h i* Cluster of female Medusæ with less advanced eggs.—*o* Peduncle of the mouth with short globular tentacles.—*c* Individuals with globular tentacles, upon which no Medusæ have as yet appeared, or from which they have already dropped.

Fig. 25.



HYDRACTINIA POLYCLINA, Ag.

a a Sterile individuals.—*b* Fertile individual, producing male Medusæ.—*d* Clusters of male Medusæ.—*o o* Proboscis, with the mouth at the apex.—*t* Elongated tentacles of the sterile individuals; in the fertile one *b*, they are simple knobs upon the proboscis *o*.

compound communities of Hydroids are attached to the ground, those of Siphonophoræ are free; but this is not a character exclusively peculiar to them, for among the Polyps we have also free communities belonging to the same order as others that are immovably attached to the ground. Such are the genera Renilla, Pennatula, Virgularia, Veretillum, etc., which are inseparable from the genera Gorgonia, Alcyonium, Xenia, Tubipora, etc., or at least belong to one and the same order. In these locomotive Halcyonoids the individual Polyps are identical among themselves, but grouped together in the most diversified ways, varying in that respect quite as much among themselves as the fixed Halcyonoids. In Pennatula and Virgularia they form regular rows upon the two sides of a feather-like stem, in Veretillum they are scattered around a cylindrical stem, in Renilla they are arranged in symmetrical lines upon the surface of a kidney-shaped disk. And yet these communities move and act as one individual. I have frequently seen Renilla, which is our only genus of free Halcyonoid Polyps, move slowly about in the sand, its stem buried in a vertical position with the disk spread horizontally.

Now, if I have succeeded in showing that, by their structure, the so-called Hydroid Polyps are not Polyps, but Acalephs, and if I should also succeed in showing that the different kinds of individuals forming the communities of Siphonophoræ have the same structure as the Hydroids, and present everywhere, in all their parts, special homologies with the Hydroid Polyps and naked-eyed Medusæ, without even exhibiting one of the peculiar characteristics which distinguish the true Polyps from the Hydroids, I should then have proved that the Siphonophoræ are really Hydroid Acalephs, and not Polyps, as Kölliker believes them to be. The evidence thus adduced would be an additional reason for keeping the true Polyps, the so-called Anthozoa, by themselves, in a distinct class.

Fig. 26.

PHYSALIA ARETHUSA, Til.

a Blunt end of the air sac, supporting the whole community, at which the youngest buds may be found.—*b* Open end of the air sac.—*c* Crest of the air sac.—*m* Bunches of single individuals.—*n* Tentacle contracted.—*t t* Tentacles of the largest kind extended.

Let us therefore compare more in detail the different kinds of Siphonophoræ with the different kinds of Hydroids and naked-eyed Medusæ. Beginning with Physalia (*Fig.* 26), it is not difficult to perceive that the various kinds of appendages which hang from the floating air-bag of that animal may be compared to the heterogeneous individuals of an inverted Hydractinia. Fancy the channelled layer which forms the attached base of Hydractinia to be swollen into a large oblong bag, and the comparison may be carried even into the details; for the essential difference between these two genera does not so much consist in a difference of the individuals forming these communities, as in the form of the basis to which the individuals are attached. In Physalia that basis is a sac, inverted upon itself, the inner bag of which, opening externally, is filled with air; the intervening cavity, communicating with the open bases of the pendent individuals, contains a greater or less quantity of fluid. Now, suppose the air-bag to be turned inside out, there would be formed a large and simple hose, containing liquid that may be pressed into the individuals attached to it, or to which the individuals may add by pouring their fluid contents into the bag. In Hydractinia, the narrow anastomozing tubes, in the basis of attachment of the polymorphous individuals of the community, may be compared to this hose of the Physalia, only that they are branching. But as a number of individuals arise from each of these stems, we may just as well consider their basis as a single tube; and then the only difference between Hydractinia and Physalia would be the narrowness of the tube of the former, and the great width of that of the latter. But reduce the diameter of the one or swell the cavity of the other, and all difference disappears, especially if we suppose them both floating or both attached. It may be that the crest of the Physalia, with its many chambers, carries the homology with the anastomozing tubes of the Hydractinia still farther.

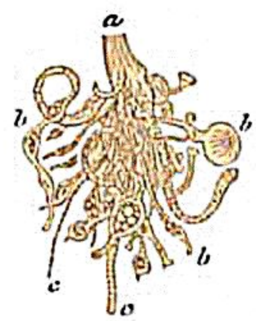
As to the various kinds of individuals forming these communities, we find first in Physalia the numerous so-called suckers, or Polyps (*Figs.* 27 *b b* and 28 *b b*), corresponding to the larger trumpet-like individuals of the Hydractinia community (Pl. XVI. *Fig.* 1 *a*, 1 *d*). These suckers, very numerous, and also much diversified among themselves, are genuine Hydroids. I have seen them feeding greedily upon small fishes, and gorging themselves to such a degree that the silvery scales of their prey could be distinctly seen through their distended walls. But these so-called "Polyps" have nothing of the polyp structure about them, neither radiating partitions dividing their internal cavity, nor tentacles opening directly into radiating chambers, nor an inverted sac hanging in that cavity; on the contrary, the edge of their oral opening is turned outward as in all Hydroids. They are, in fact, Hydroids of the simpler kind, but not so simple as some of the individuals of the Hydractinia communities; for though they have no whorl of tentacles around their mouth, they have at least one very long and very complicated tentacle. Of these tentacles there are two kinds,—larger ones connected

Fig. 27.

Bunch of single Hydræ and clusters of Medusæ of PHYSALIA ARETHUSA, Til.

b b The Hydræ, with their tentacles *c c*.—*d d* The bunches of Medusæ.

Fig. 28.



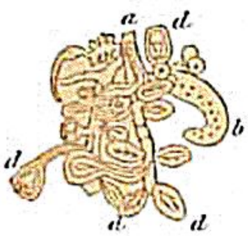
Bunch of Hydræ of PHYSALIA ARETHUSA, Til.

In various states of contraction and expansion.

a The hollow base of attachment of the whole bunch, communicating freely with the chymiferous cavity of the air sac.—*b b b* Single Hydræ.—*c c* Tentacles.

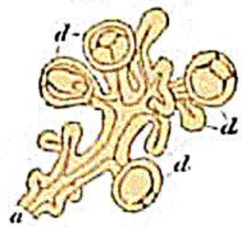
with the larger so-called Polyps, and smaller ones connected with the smaller individuals (*Fig.* 28 *c c*). These two kinds of individuals seem to be always distinct, and some of them never even gape at their outer end. The individuals of these two kinds form large clusters, small communities as it were, connected with the larger community. There is a third kind of individuals, smaller than either (*Fig.* 27 *d d*), which are fertile, and upon the neck of which arise numerous Medusæ buds, presenting all the characters of the naked-eyed Medusæ; that is, having, like them, four radiating tubes and a circular tube (*Fig.* 29 *d d*). These Medusæ form clusters so similar to the bunches of Medusæ that hang from the genuine Tubularia, that they might easily be mistaken one for the other (*Fig.* 30). (Compare Pl. XXIV. fig. 1 with *Fig.* 29.) Here, then, is a Siphonophorous community, in every respect similar to a Hydroid community, consisting of various kinds of Hydroids, from some of which are produced Medusæ buds, as in ordinary Hydroids. The fact that in Physalia these Medusæ buds do not separate from the community but wither upon the stock from which they arise, is not peculiar to this group of animals; since we have already seen, that, in the family of Tubulariæ, we have those that produce free Medusæ, the genus Hybocodon and others, the genera Tubularia (*Fig.* 30), Thamnocnidia, and Parypha, the Medusæ of which do not separate from their parent stock. These facts are in themselves sufficient to show that the Physalia community does not consist of aggregated Polyps, but of aggregated Hydroids; and that in a natural classification they cannot be referred to any other order than the Hydroids, though in that order they constitute a distinct family.

Fig. 29.



Bunch of Medusæ of PHYSALIA ARETHUSA, Til.
In various stages of development.
a Common hollow base of attachment of the whole bunch, communicating with the chymiferous cavity of the air sac. — *b* So-called Polyp, or sucker. — *d d d d* The Medusæ buds.

Fig. 30.

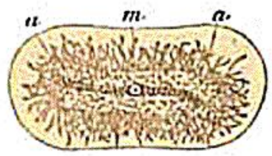


Bunch of Medusæ of TUBULARIA COUTHOUYI, Ag.
a Common axis. — *d d d* Mature Medusæ, already withering.

The idea of considering the Medusæ buds of these communities as the sexual organs of the Hydroids is not admissible; for we have seen that these buds may become independent and free, and that in due time they acquire themselves distinct sexual organs, some individuals being provided with ovaries the eggs of which undergo all the changes through which ordinary eggs pass until new individuals are formed in them, while other individuals are provided with spermaries which at the time of spawning are filled with spermatic particles. Now, unless sexual organs can themselves have distinct sexual parts of both sexes, all these so-called sexual organs of the Hydroids must be considered as naked-eyed Medusæ, which are not freed from their parent stock as is the case with others.

Velella and Porpita consist of compound communities like Physalia, only that here the diversity of the Hydroids attached to a common base is not so great, there being, in fact, only two kinds of individuals: the sterile ones, among which that occupying the centre of the community is larger than the others, like the top animal of the Madrepores, and around it, clustered together, a large number of smaller ones; and outside, the large fertile individuals (*Fig.* 32) from which Medusæ buds arise that become free, and are very similar to the common Oceania among the naked-eyed Medusæ. This, at least, is the case in Velella (*Figs.* 31 and 32), as I shall show hereafter more fully. Meanwhile the wood-cut below (*Fig.* 33) represents an Oceania-like Medusa that freed itself, with many others, from the larger fertile individuals of the common Velella of the Gulf of Mexico, represented in *Fig.* 31. The individuals forming the communities known as Velella and Porpita have no more the structure of Polyps than those of the Physalia. They are genuine Hydroids.

Fig. 31.



VELELLA MUTICA, Bosc.
m So-called mouth — *a a* So-called tentacles.

Fig. 32.

Single so-called tentacle of VELELLA MUTICA, Bosc, Bearing Medusæ buds *d d*. — *a* Base of attachment. — *b* Blunt end of the tentacle.

Fig. 33.

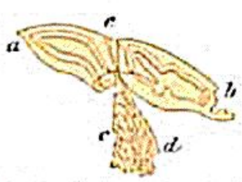
Free Medusa of VELELLA MUTICA, Bosc.
o Proboscis. — *b* Radiating chymiferous tube. — *c* Circular tube.

If from these we pass to the Diphyidæ, we notice a long string of heterogeneous individuals suspended larger elongated, bell-shaped individuals, commonly called the swimming-bells, and generally considered as organs destined to move the whole community (*Figs.* 34 and 35). But I believe that this view is not correct, but that, on the contrary, these so-called swimming-bells are themselves distinct individuals of one kind connected with smaller individuals of other kinds, forming together a community composed of very heterogeneous elements. The invaluable investigations of Gegenbauer upon the development of Diphyes seem to me to leave no doubt upon this point; for he has observed the whole development of the egg of one of these animals, showing that the process of segmentation of the egg terminates in the formation of one of these so-called swimming-bells. Now, the product of the egg, whatever it may be, cannot be a mere organ. It is unquestionably a young animal; and that animal, as represented by Gegenbauer, is a genuine naked-eyed Medusa. It has the four characteristic radiating tubes, a circular

Fig. 34.

DIPHYES SIEBOLDII, Köll.
(*Copied from Kölliker.*)
a b Anterior and posterior swimming-bells. — *c* Base of the axis of the community. — *c* Main axis of the community, with young buds. — *d d* Fully developed buds, with their feelers.

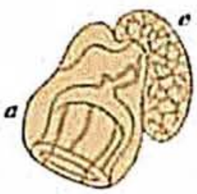
Fig. 35.



GALEOLARIA FILIFORMIS, Leuck.
Diphyes quadrivalvis, Gegenb.
(*Copied from Gegenbauer.*)
a b Anterior and posterior swimming-bells. — *c* String of twin individuals. — *d* Feelers with lasso cells. — *e* Cæcal termination or base of the connecting tube or axis.

tube, and even the inverted rim of the margin of the bell so constant in naked-eyed Medusæ (*Fig.* 36); and though no mouth is described, I can hardly suppose that it is wanting. The radiating tubes imply the circulation of a fluid, and that fluid is in all naked-eyed Medusæ derived from the surrounding medium, and introduced either through a proboscis or through a cruciate opening in the centre leading into the radiating tubes. The fact that in Staurophora[1] I have found an immense mouth where none was suspected, leads me to suppose that this young Diphyes and the so-called swimming-bells of the Siphonophoræ generally, must have such an oral opening, which has probably not been remarked only because such an opening would not be looked for in what was supposed to be a mere organ. Yet, considering the strict homology between the open Polyps, so called, and the closed sacs mixed with them in Physalia, and like them provided with tentacles, it may be that the swimming-bells are not open externally, and only communicate with the main axis.

Fig. 36.



Embryo of DIPHYES SIEBOLDII, Köll. (*Copied from Gegenbauer.*)

e Remnant of the embryonal body. — *a* Swimming-bell developed from the embryonal body.

Be this as it may, the swimming-bells of the Diphyidæ cannot be compared to the swimming-bag of the Physalia, which, as we have seen, is the common base of all the Hydroids of that community; nor is it homologous to the so-called swimming apparatus of the Physophoridæ. The only part in these different communities really identical in all Siphonophoræ is the canal marked *c* in *Figs.* 34 and 35, along which hang the heterogeneous individuals of the community in Diphyidæ, Physophoridæ, and Physalidæ; in the same manner as the many individuals of the common Hydroids are attached to their hollow axis. In Diphyes proper there exist, generally, two so-called swimming-bells of nearly the same size, though occasionally but one is observed, and in others the lower one appears sometimes so much smaller than the upper one, that, taking these facts in connection with the facts observed by Gegenbauer respecting the origin of the first swimming-bell from an egg, it is natural to infer that the second swimming-bell arises from the main tube of the first, and gradually enlarges to the same size; in the same manner as in the proliferous naked-eyed Medusæ (*Figs.* 12, 13, and 14), in which one of the four radiating tubes becomes the basis of attachment of numerous lateral bells. It is farther to be observed, that the pendent string of Diphyes, with its numerous individuals, is only a continuation of that same tube which connects the two swimming-bells, and that the individuals attached to it arise also as buds from it. But here we perceive a variety of parts which require our special attention.

The individuals described as Polyps, or suckers, in Diphyes, are as it were

[1] AGASSIZ (L.), Contributions to the Natural History of the Acalephs, Part. I. p. 300.

protected by a flattened, scale-like, gelatinous body (*Fig.* 37 *a a*), and between the scale and the Polyp hangs a complicated tentacle, *c d*. These individuals I consider to be identical with the Hydroids of the Physalia, the so-called Polyp representing the proboscis, as we observe it in Coryne and Clava, only that each is provided with a single tentacle and surrounded by a protecting scale. Now, if I am not greatly mistaken, that protecting scale must be considered as a sort of bell, analogous to that of Campanularia, but gelatinous, and split open on one side; and the so-called sexual organs (*Fig.* 37 *m*) of these so-called Polyps are genuine Medusæ buds, with a proboscis, four radiating tubes, and a circular tube, with a diaphragm around the rim, exactly as in naked-eyed Medusæ, producing eggs or spermatic cells upon the proboscis, according to the male or female character of the different individuals, exactly in the same manner as in Sarsia or Hippocrene.

Fig. 37.

Two twin individuals of the pendent string of the community of DIPHYES SIEBOLDII, Köll.
a a The so-called scales. — *b b* The so-called Polyps. — *m* The so-called sexual capsule. — *c* External feeler, with lasso cells. — *d* Feeler contracted.

We have, then, in a Diphyes community, three kinds of individuals.[1] First, one or two, or sometimes three, Medusoid individuals at the base of the stock; secondly, a large number of more Hydroid-like individuals hanging connected with the pendent string, but differing from the common Hydroids in having an open, gelatinous, somewhat Medusoid bell, commonly called scale; and, thirdly, arising from the base of the proboscis of these Hydroids, genuine Medusæ buds that are either male or female, and which can no more be considered as the sexual organs of these so-called Polyps, than those of the types already considered, since they are themselves provided either with an ovary or a spermary.

The Diphyes community presents another peculiarity, highly important with reference to a correct appreciation of the Medusoid character of the genuine Hydroids. In most of these, we find that every individual consists chiefly of a bell-shaped or trumpet-shaped or club-shaped sac, with tentacles around the central opening, or upon its sides or around its base, comparable, indeed, in every respect, to the proboscis of the naked-eyed Medusæ as it exists in Sarsia. But though the body of the individual Hydroids appears more or less bell-shaped, as in Tubularia and still more in Campanularia, yet that bell is not hyaline and gelatinous like the bell of the Medusæ proper, while the so-called scale of the Diphyes is so, thus forming a sort of transition to the so-called swimming-bells, in which the radiating and circular tubes are fully developed, as in ordinary Medusæ, but at the expense of the proboscis, which is wanting. This would at once explain why the

[1] For illustrations of this and the following families I would refer to the papers of Gegenbauer, Huxley, Kölliker, Leuckart, and Vogt, quoted page 27, notes 5, 10, 11, 12, and 13.

Hydroids proper have no radiating tubes, while their Medusæ buds have them fully developed. I suppose the case to be this: That a perfect Medusa has two distinct structural elements, the disk or bell with its radiating tubes, and the proboscis with the mouth, and that in Hydroid communities the different individuals present one or the other of these two elements, singly developed or more or less combined; while their Medusæ buds have always the characteristic features of perfect Medusæ, and are always sexual, whereas the Hydroids are never so, whether the proboscidal or the bell element be the more prominent. If this be true, then the characteristic feature of a Diphyes community consists in the more Medusoid character of some of its Hydroids, while the more numerous individuals resemble the common Hydroids more, and, like those, produce the sexual Medusæ buds. We have already seen, in the family of Tubulariæ (p. 45), analogous combinations of characters; some of the fertile buds of these Hydroids being more Medusoid in their structure than others.

The peculiarities of the genus Abyla (Calpe) seem to confirm this view. We have here also, as in most Diphyes, two so-called swimming-bells, only that the first is much smaller and less Medusa-like than the second, and that the so-called Polyps of the pendent string are not protected by simple scales, but by a cap resembling the first swimming-bell, with this additional peculiarity, that the tentacles are more or less removed from the base of the Polyps.

The genus Praya is very closely allied to the genus Diphyes, but its two swimming-bells are placed side by side, and the pendent string consists of Hydroids with a distinct helm-shaped bell, from which arise the Medusæ buds. This string of twin individuals, one of which is a Hydroid with a helm-shaped bell and another a genuine Medusa, has been described as a string of single individuals, the Medusa buds being considered as their sexual organ, but with as little propriety as in the genuine Diphyidæ, for these buds again are themselves sexual. The so-called single individuals of all Diphyide are not single beings, but twins, one of which is Hydroid, and the other Medusoid, in its structure; and these twins drop together and swim about freely as independent individuals.

In the genus Vogtia, the so-called swimming-bells have a quadrangular shape, somewhat like a contracted Staurophora, and though no radiating tubes have been described in them, I doubt not that they will be found when sought for. Below the pyramid of these Medusoid Hydræ, there are a few simple, sucker-like Hydroids, and from the lower part of the axis arise the sexual Medusæ buds, with enormous proboscides, covered either with eggs or spermatic cells, projecting far out of the Medusa bell, as is sometimes the case with those Sarsias that are not detached from their stem. (Pl. XVII. *Figs.* 13, 14, 15, and 16.) In the genera Hippopodius and Elephantopus, which are certainly distinct, though frequently considered as synonyms, the swimming-bells are boat-shaped, and their radiating tubes winding, as in Galeolaria among the Diphyidæ. In the genus Athorybia, the swimming-bells have the shape of arched ribs; and, though no radiating tubes have been described in them, I doubt not that they will be found, unless there exist here, as in Tubularia, various combinations of the more Hydroid or more Medusoid features. In the genus Apolemia, the swimming-bells resemble those of Physophora, and the Hydroids are arranged in clusters, hanging at intervals, along the main axis.

The genus Physophora, with its double row of bottle-shaped swimming-bells, approaches more nearly Hippopodius and Vogtia than Agalmopsis and Forskâlia; for the sucker-like Hydræ are few (*Fig.* 38), at the base of the axis, as in Vogtia, and the Medusæ buds form small bunches. In Agalmopsis, on the contrary, there is below the double row of heart-shaped swimming-bells a long string of large Hydroids, provided with protecting scales and furnished with tentacles, and their sexual Medusæ buds form small bunches, suspended at considerable intervals between them. In Forskâlia, finally, the more or less quadrangular swimming-bells, arranged in several rows, form a long cone, from which hang two kinds of Hydroids, one protected by, and the other without, scales; and it is from the cluster of the latter that arise the male and female Medusæ buds.

Fig. 38.

YOUNG PHYSOPHORA,
(*Copied from Gegenbauer.*)
e Buds of swimming bells.—*b b* So-called tentacles; lower *b* so called Polyp. — *c c* Feelers with lasso cells. — *r* Air sac.

It is plain, from this rapid survey of the Siphonophoræ, that, with the exception of Physalia, Velella, and Porpita, which consist of Hydroids only, they all agree in having a set of more or less numerous Medusæ-like Hydroids at the base of their common axis; and that from the prolongation of this axis arise other Hydroids, either altogether resembling the common Hydroids, without a bell, or protected by a scale-like open bell, in a measure intermediate between Medusæ and Hydroids; and that, finally, all produce Medusæ buds. These Medusæ buds mostly wither upon the community, though in some they free themselves in the shape of twin individuals composed of a Hydroid and a Medusa, which have been described as distinct genera, under the names of Eudoxia, Aglaisma, etc.

It follows from all this, that while the Siphonophoræ must be united with the Hydroids proper in one order, on account of the identity of their structure and of the similarity in the degree of complication of that structure, the types of this order in which the community consists of more Medusa-like Hydræ, such as the Physophoridæ and Diphyidæ, must constitute a sub-order by themselves; Physalia, another sub-order, on account of the peculiarity of structure of the common base of the community; Velella and Porpita, another, for similar reasons; and the true

Hydroids, a fourth: unless we separate at once the Sertularians with their horny stem and bell as a sub-order, distinct from the Tubularians, with their soft Hydroids, which seems to be the more appropriate course. Diphyidæ and Physophoridæ may require to be subdivided in the same way.

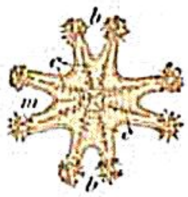
Now that the investigations of Olfers, Leuckart, Quatrefages, and Huxley, have made us as fully acquainted with the structure of Physalia as we are with that of the other Siphonophoræ, it is hardly worth while to recall the opinion of DeBlainville upon these animals, as it is evident from his description, that he could never have entertained such views about them, had he ever had an opportunity of studying them for himself. DeBlainville considered Physalia as a single animal, which he referred to the type of Mollusks in connection with the Heteropod Gasteropods, considering the crest of the bladder of Physalia as its foot, similar to that of these Gasteropods, and the pendent appendages as gill-like organs similar to those of the Dorsibranchiate, while he describes the opening of the bladder as their mouth. But I myself have had repeated opportunities for examining Physalia alive, and this examination has left no doubt on my mind that it constitutes a compound community of a great variety of individuals, presenting all the characters of true Hydroids.

It is important here to remark, that this great discrepancy in the opinions expressed respecting the affinities of these animals was in a measure owing, either to an insufficient acquaintance with their true structure, as was no doubt the case with Blainville when he referred Physalia to the type of Mollusks, and with Vogt when he referred the Ctenophoræ to the same type, or to a want of familiarity with the other objects associated with them, as is no doubt the case with the German authors, who, from a want of opportunity of examining Corals alive, have so generally united the Hydroids and Siphonophoræ with the Polyps. It is a remarkable circumstance, that the naturalists who have known the Polyps best, as Milne-Edwards and Dana, never thought of associating the Siphonophoræ with them, though they were equally acquainted with both, and though we owe to Milne-Edwards in particular, some of the most minute investigations extant upon the Siphonophoræ. As to the Hydroids, though they are associated by Milne-Edwards with the Polyps, he considers them as forming by themselves a natural division in that class, coequal with the Halcyonoids and Actinoids; while Dana goes one step farther in the right direction, by uniting the Halcyonoids and Actinoids in one natural division, to which he opposes the Hydroids as another division of equal value. But even this position Dana has lately abandoned, and he now unites the Hydroids with the true Acalephs; so that it may be truly said, that, in proportion as our knowledge of the Siphonophoræ, the Hydroids, and the Polyps, has gradually advanced, naturalists have perceived more and more distinctly the

Fig. 39.

LUCERNARIA,
Seen in profile.
a Peduncle. — *b b* Tentacular bunches.

Fig. 40.



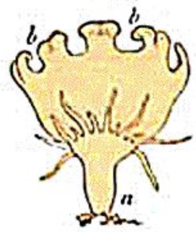
LUCERNARIA,
Seen from above.
m Mouth. — *c c* Ovaries. — *b b* Tentacular bunches.

fundamental differences which distinguish the Polyps from the Acalephs, and at the same time incline more and more towards uniting the Hydroids as well as the Siphonophoræ with the genuine Acalephs. Incidentally, I would also remark that I entertain no doubt respecting the Hydroid affinities of Lucernaria (*Figs.* 39 and 40). Moreover, their resemblance to the young Medusæ is very great (*Figs.* 41, 42, and 43), especially during the incipient stage of their Strobila state of development.

Fig. 41.

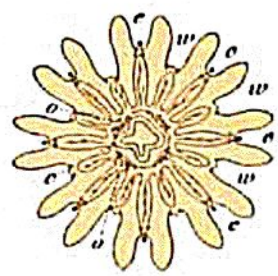
Scyphostoma of
AURELIA FLAVIDULA, Pér. & LeS.
In this stage of growth, Aurelia is simply a Hydroid.

Fig. 42.



Strobila of
AURELIA FLAVIDULA, Pér. & LeS.
a Scyphostoma reproduced at the base of a Strobila *b b*, all the disks of which have dropped off but the last.

Fig. 43.



Ephyra of
AURELIA FLAVIDULA, Pér. & LeS.
c Mouth. — *e e* Eyes. — *o o* Ovaries. — *w w* Tentacular spaces.

The types referred to the class of Polyps are not less diversified than those referred to the class of Acalephs; nor do the different writers upon that subject agree more closely in the views which they entertain respecting their affinities. The type which has always been considered as forming the bulk of the class of Polyps is that of the Corals. The Actiniæ have been by turns associated with them, and separated from them. As we have already seen, the Hydroids have also, for a long time, been united with them by all naturalists, until doubts arose respecting the correctness of this combination, in consequence of the discovery of alternate generations among them. Besides these we find, farther, the Bryozoa united with the Polyps even to this day by many naturalists; though the researches of Milne-Edwards and Audouin,[1] published more than twenty years ago,

[1] EDWARDS (H. MILNE) et AUDOUIN (J. V.), Recherches sur les animaux sans vertèbres faites aux îles Chausey, Ann. Sc. Nat. II. p. 20. — Milne-Edwards alone published more extensive accounts of those observations: Recherches Anatomiques, Physiologiques, et Zoologiques sur les Polypes; Ann. Sc. Nat. 2de sér. 1838, IV. p. 321; 1840, VI. p. 5; 1841, VIII. p. 321; and 1842, IX. p. 193. The opinion that the Bryozoa are not Polyps, but a low type of Mollusks, had already been expressed by K. E. v. Baer, in 1827, in his Beiträge zur Kenntniss der niedern Thiere, Nova Acta Academiæ Naturæ Curiosorum, Vol. XIII.

might have satisfied any unprejudiced investigator that they are not Polyps, nay, not even Radiata, but a kind of low Mollusks.[1]

What are commonly called Corals are communities of individuals possessing a solid frame, but of the most heterogeneous structure, and having no common character except the solidity of their frame. The moment we take into account the anatomical structure of the beings forming such communities, we must distinguish several kinds of Coral stocks. First, those which are uniformly calcareous, formed by genuine Polyps allied to the Actiniæ. In fact these Coral stocks differ from the Actiniæ only by the presence of solid deposits in the walls of their body. Such are the Astræans and Madrepores, all of which have, like the Actiniæ, numerous simple tentacles, and a digestive cavity hanging below the mouth, as well as radiating partitions projecting into the main cavity of the body, and to which the ovaries and spermaries are suspended. Secondly, on account of the similarity in the organization of their individuals, we would unite, as another group of Corals, the various solid stocks formed by Halcyonoid Polyps. Some of them are calcareous, like the Actinoids, the Red Coral, for instance; others are horny, the Gorgoniæ; and others consist of calcareous tubes, such as Tubipora. The Corals of these Halcyonoid Polyps are, it is true, far more diversified than those of the Actinoids, though there seems to be much less difference between the animals themselves than among the latter. They all have eight fringed tentacles, and agree fully in this respect, as well as in their general structure, with those Halcyonoids which have no solid frame at all, as the genera Halcyonium and Renilla, or only a simple horny rod in their axis, as Virgularia and Pennatula.

On account of the special homologies of the Actinoids and Halcyonoids, there can be no doubt that these two types of Polyps belong to one and the same natural group, as Dana has first shown. They all have vertical radiating partitions dividing the main cavity of the body into chambers, which communicate freely with the cavity of the tentacles; in all, the ovaries and spermaries are found hanging freely from the free inner edge of these partitions, and in all there is a distinct digestive sac suspended in the upper part of the main cavity of the body. They are, in one word, strictly homologous to the Actiniæ, the structure of which we have considered more fully above.

Among the Stony Corals generally referred to the Actinoid Polyps there is one

[1] Siebold in his Text-book of Comparative Anatomy, and Kölliker in his Schwimmpolypen, referred to above, (p. 27, note 12.) still unite the Bryozoa with the Polyps. Kölliker is particularly explicit on that point, and believes that the expression by which Mollusks and Radiates may be clearly distinguished has not yet been found. But, surely, *bilateral* animals with an *alimentary canal* open at both extremities and *bent in a plane dividing the body into equal halves* can no longer be associated with Polyps, which are built upon a plan characterized by *radiation around a vertical axis*.

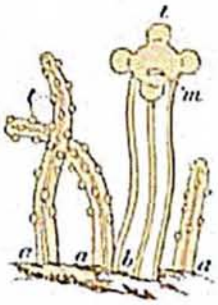
type, belonging to the order of Tabulata of Milne Edwards (*Figs.* 44, 45, and 46), formed by animals entirely different from the true Actinoids, and closely allied, as I shall show hereafter, to the genus Hydractinia, constituting a third type of

Fig. 44.

MILLEPORA ALCICORNIS, Lmk.

A branch of the Coral of that name, natural size. The little projections along the edge are meant for the extended Polyps. They are extremely shy and delicate, and never show themselves again after a branch has once been taken out of the water.

Fig. 45.



MILLEPORA ALCICORNIS, Lmk.

Magnified view of the extended Polyps or Hydroids of the same Coral stock.

a a Smaller Hydroids. — *b* Larger Hydroid, *m* its mouth, *t* its tentacles.

Fig. 46.

MILLEPORA ALCICORNIS, Lmk.

Transverse section of a branch of the Coral stock, magnified.

a a Pits of the Hydroids, with their successive floors. It is very difficult to obtain sections of the pits occupied by the smaller Hydroids.

Coral stocks, which, on account of its Hydroid affinities, must be united with the class of Acalephs. Moreover, these Corals differ greatly from those of the Actinoid Polyps. The pits into which the animals retreat have a horizontal floor extending from wall to wall, and these floors are built successively one above the other, as the animal rises, the radiating partitions never extending vertically through successive floors. Not so with the Actinoid Polyps, in which the radiating partitions extend from the top to the bottom of the pit, while the horizontal floors, if they exist, extend only from one radiating partition to the other.

Among Bryozoa we find a fourth type of Corals. These Bryozoa are constructed on a totally different plan, and exhibit a perfect bilateral symmetry; for even the whorl of feelers which surrounds the mouth is not circular, but, like a horseshoe, presents two symmetrical halves. From the mouth arises an alimentary canal, extending in the longitudinal axis of the body, which bends itself in the same plane, and, extending again forward, opens below the mouth. There is here no sign of the characteristic partitions and chambers of the true Polyps, nor of the radiating and circular tubes of the true Acalephs: so that we need not even take into consideration their bilateral structure, in order to satisfy ourselves that their true position cannot be either with the Polyps or with the Acalephs; while their relation to the Ascidians and Brachiopods, and especially to the latter, is so close as to place it beyond question now, that their true affinities are with the Mollusks, and not with the Radiates.

I shall hereafter have an opportunity of showing that the comparative simplicity of these animals is no evidence of any relation to the Polyps. The primary question to be decided, in considering the true relations of animals, is not one of complication of structure,[1] which determines the orders in a class, but one of plan, which stands even above the consideration upon which classes are founded, and determines the four great branches into which the whole animal kingdom is divided. As to the Coral stocks formed by Bryozoa, they vary greatly, being calcareous in some, as in Eschara; horny in others, as for instance in Achamarchis; and in others again, as in Halcyonidium or Holodactylus, altogether gelatinous. Moreover, these Bryozoan Coral stocks never exhibit in the cells occupied by the animals, those radiating lamellæ so characteristic of the Coral stocks of the Actinoids. On the contrary, these cells, into which the animals may withdraw and conceal themselves entirely, are perfectly smooth, and the opening through which the animal is protruded presents uniformly a transverse, oblong, or crescent-shaped aperture, similar to the gaping opening between the valves of a Lingula, or the half-open shells of any other Brachiopod, with which they are much more closely allied than would at first appear. These cells are external, and do not form a part of the body-wall of the animal, as do the radiating pits of the Actinoids. The so-called arms of the Brachiopods are truly homologous to the marginal fringes of the Bryozoa, between the branches of which the mouth is placed in both. It is therefore evident, that, notwithstanding the high authority of some of our best anatomists, the Bryozoa must be removed altogether, not only from the Polyps, but also from the type of Radiata, and referred to that of the Mollusks. The presence of a Coral stock in most of them can no longer have the slightest weight in determining their affinities; since we have already seen that there is a kind of Coral stock, the Millepora, formed by certain Hydroids of the same type as Sertularia and Campanularia, or, rather, closely allied to Hydractinia, which truly belong to the Acalephs; and since, among the genuine Polyps themselves, we find Corals so diversified as those of the Astræans and Madrepores, of Gorgonias and the Red Coral, and of Tubipora. Under these circumstances, it must be self-evident that the name of Corals can no longer be applied to designate a natural group of animals, but only certain modes of association of animals belonging to very different

[1] I have already insisted upon this point in the first volume of this work (p. 143), and in the chapter on Embryological Systems (p. 220). Baer was the first to establish a clear distinction between the degree of perfection in the structure of animals and the plan upon which that structure is built, a distinction which Cuvier had not reached when he allowed the Intestinal Worms to remain among the Radiata on account of the simplicity of their structure. The same confusion remains in the minds of those who consider the Worms as a distinct branch of the animal kingdom, and associate with them the Rotifera and even the Bryozoa. With reference to the Bryozoa and Polyps it is essential to remember, that, though the body in both may be called a sac, in Polyps this sac is a *radiating* sac, while in Bryozoa it is a *bilateral* sac; i. e., the one is built upon one plan and the other upon another plan. In Polyps the fundamental idea is *radiation*, in Bryozoa *bilateral symmetry*.

types. The discovery that the Millepora is a genuine Hydroid, and not at all allied to the Actinoids, makes a farther revision of all these Stony Corals, the animals of which have not yet been sufficiently investigated, particularly desirable. This is especially the case with Pocillopora (Pl. XV. Fig. 14ᵇ), which, from the structure of the Coral stock itself, I am now satisfied, must also be referred to the Hydroids with Millepora.[1] I believe the same also to be the case with Seriatopora (Pl. XV. Figs. 15 and 15ᵇ).

There is a fifth type of Coral stocks, still more remote in its structure from the Polyps, which, as long as all Corals were considered to be Polyps, was, with the rest, referred to that class. I allude to the so-called Corallines and the Nullipores. When referring them to the Polyps, Lamarck assumed that there existed animals of a very soft nature upon their surface; which, however, could not retreat into distinct cells, and therefore left no mark of their existence upon the dried Coral stock. But since these Corallines have been more carefully examined, no trace of such animals has been observed; and, to say the least, their animal nature has become very questionable. For my own part, I entertain no doubt, that, as the investigations of Decaisne[2] first showed, they are neither more nor less than genuine Algæ with a tissue largely loaded with calcareous particles, and may fairly be designated under the name of Limestone Algæ. They are true plants of the lowest type, forming, in consequence of the large amount of lime they contain, Coral stocks of no small importance in the economy of the Coral reefs. It is by their agency, since they are capable of sustaining their life even when not permanently under water, that the crest of the Coral reef is raised above the level of low-water mark; and the growth of some of their representatives is so extensive that the exposed part of a large number of the islands of the Florida reef is almost entirely composed of the fragments of these calcareous sea-weeds. I have seen large slabs of rock, used in the construction of the foundations of Fort Jefferson, upon the Tortugas Islands, composed entirely of the joints of these calcareous sea-weeds, which were so distinct as to be recognized with ease.

[1] As the structure of the Coral stock of the Tabulata of Milne-Edwards presents in all the same general features, it is highly probable that the whole order will have to be referred to the class of Acalephs. I am farther inclined to believe, that the Rugosa will share the same fate. Their typical structure seems to be a combination of the characteristics of Lucernaria and the Strobila state of the higher Discophoræ. A section of Strombodes recalls at once the appearance of a Strobila.

[2] DECAISNE (J.), Essais sur une classification des Algues et des Polypes calcifères, Ann. Sc. Nat. 2de sér. 1842, XVII. p. 297. — Mémoire sur les Corallines ou Polypiers calcifères, Ann. Sc. Nat. 2de sér. 1842, XVIII. p. 96. See also LINDLEY, Vegetable Kingdom, London, 1853, 1 vol. 8vo. p. 23. — KÜTZING, Phycologia Generalis. — HARVEY, a Manual of the British Marine Algæ, London, 1848, p. 103. Schweiger already refers the Corallines to the Algæ.

It is evident that these Corallines ought to be eliminated from the class of Polyps, since their vegetable nature is proved.

There are a few more animals which have been referred to the class of Polyps, such as the Lucernaria, the Eleutheria, and the fresh-water Hydra,[1] about the affinities of which I shall have more to say hereafter, when considering in detail the Hydroids and their alternate generations. I leave them aside for the present, as, on account of their small number of representatives, their position in the natural system can in no way affect the natural limits of the classes of Acalephs and Polyps. I shall also take occasion to present some considerations upon the affinities of the Rugosa,[2] a type entirely unknown at the present day, but the representatives of which are found, in large numbers, in the oldest stratified rocks forming part of the crust of our globe. So long is it since the Tunicata were removed from among the Zoöphytes, that there is hardly a naturalist living who may remember the time when they were confounded with Polyps. I need not, therefore, insist here upon their affinities with the Mollusks.

SECTION III.

THE CLASSES OF RADIATA.

We have thus far considered the various types of animals, chiefly with the view of ascertaining which among them are true Radiata and which are not; and it appears plainly, even from this rapid sketch, that while the Ctenophoræ, the Medusæ proper, the Siphonophoræ, the Hydroids, the Halcyonoids, and the Actinoids, are truly radiated animals, this is not the case with the Bryozoa, which properly belong to the type of Mollusks, nor with the Corallines, which are genuine Plants.

[1] Milne-Edwards refers the genus Hydra to the same class, to which he refers also the Anthozoa, the Tabulata, and the Rugosa, which he calls Zoantharia, separating, however, the genus Hydra, as a distinct sub-class; Leuckart, on the contrary, places it among the Hydroids proper. Many important papers have lately been published upon the structure of this type, but with conflicting results. While this page was in the printers' hands I received No. 31 of the Quarterly Journal of Microscopical Science for April, 1860, in which I find Prof. Allman's description of a new genus of Lucernarioid Hydroids, called Carduella, showing, more distinctly perhaps than Lucernaria proper, the Acalephian character of this family, on one hand, and also its affinity to the Rugosa, as well as to the embryonic forms of the higher Discophoræ.

[2] If, as I believe, not only the Tabulata, but also the Rugosa, belong to the Acalephs, the existence of this class upon our globe, instead of beginning in the Jurassic period, dates from the earliest geological ages characterized by the presence of organized beings. Thus far the oldest Acaleph known, was a Medusa from Solenhofen.

The question, however, now arises, whether all these radiated animals form a type distinct from the Echinoderms, as Leuckart would have it; or constitute two classes of the type of Radiata, coequal with the Echinoderms, as Cuvier represented them; or three classes, as Owen and Ehrenberg admit; or any other number of classes.

In uniting the Acalephs and Polyps into one primary division distinct from the Echinoderms, Leuckart has overlooked the general homologies which unite the Echinoderms with the Acalephs and the Polyps, and has paid no attention to the Acalephian character of the embryo of a large number of Echinoderms. There is no feature more striking in all these animals, in the Polyps and Acalephs on the one side and the Echinoderms on the other, than the radiated arrangement of their parts. A comparison of Echinarachnius with Polyclonia and Æquorea, and of the latter with Actinia, can leave no doubt upon this question; and since all Polyps can easily be reduced to the type of Actinia, as well as all Acalephs to that of Æquorea and all Echinoderms to that of Echinarachnius or of Asterias, it must be admitted that the plan of structure is the same in all these animals. They are built upon the idea of radiation; that is to say, all their organs are arranged around a centre, at which the mouth is placed, and diverge towards the periphery, to converge again at an opposite pole. But this is not the whole: all the organs of this structure are homologous. The chambers between the radiating partitions of the Actinia correspond to the radiating tubes of Æquorea, and these, again, to the ambulacral system of the Echinoderms; and the marginal tentacles of the Actiniæ correspond to the marginal tentacles of the Acalephs, and appear as ambulacral tubes in the Echinoderms, under the various forms of seeming gills around the mouth of Echinoids, or of seeming gills in the rosette of Clypeaster, or of branching tentacles and ambulacral suckers in the Holothurians. The identity of all these parts I shall have an opportunity of showing hereafter.

The central cavity, in open communication with the radiating chambers in Polyps, is closed in Acalephs, and communicates only through narrow openings with the radiating tubes; while in Echinoderms there arises a distinct alimentary canal, which is, however, still in direct communication with the ambulacral system through a network of anastomoses, about which I shall also have more to say hereafter. The ocelli at the base of the tentacles, which in Polyps are mere pigment cells, appear like modified tentacles in the higher Medusæ, while they are still connected with real tentacles in the lower ones; in Echinoderms they appear again, in the same relation with the ambulacral system and the terminal odd ambulacral sucker, as they are with the tentacles in Acalephs. The sexual organs are upon the sides of the radiating cavities; that is, upon the edge of the partitions in the Polyps, upon the sides of the radiating tubes in the Acalephs, and alternating with the ambulacra in Echinoderms,—everywhere in a homologous position and relation.

Leaving aside, for the present, some farther complication in the structure of Echinoderms, which we shall consider more fully in the latter part of this monograph, it can, finally, be said, that the Echinoderms are Acalephoid animals, the body-wall of which is loaded with limestone. Lamarck had truly perceived this close affinity between the Acalephs and Echinoderms when he united them into one great division under the name of Radiaires to the exclusion of the Polyps, calling the Acalephs "Radiaires Mollasses," and the Echinoderms "Radiaires Echinodermes." In thus closely combining these two types into one class, however, he committed an error similar to that of Leuckart, who united the Polyps with the Acalephs in one larger group, from which he excludes the Echinoderms. But the reference already made to the homology of their structure is in itself sufficient to show that Polyps, Acalephs, and Echinoderms are constructed upon the same plan, and ought therefore to be united in one and the same primary division, for which the name of Radiata, proposed by Cuvier, seems to be the most appropriate. This once settled, the question of the subdivision of the Radiata into classes becomes comparatively easy.

I take it for granted, that the distinction I have attempted to make[1] between the *plan of structure* in animals and the *mode of execution* of the plan is, if not admitted by other naturalists, at least fully understood by them; and upon this basis I now propose to discuss the limitation of the classes of Radiata. Admitting the *plan* of structure to be the criterion by which the primary groups of animals are distinguished, we have seen that Echinoderms cannot be separated from the other Radiates, since they differ only in structural complications, but not in the plan of their structure. Admitting, next, that the *mode of execution* of a given plan of structure constitutes the essential difference between classes, we have now to consider in what way the idea of radiation (upon which the plan of structure of the Radiates is founded) is carried out in different types of this branch of the animal kingdom, and with what means their body is built up; and this will furnish us with a key to find the natural limits of their classes.

The leading characteristics which distinguish the Polyps, the Acalephs, and the Echinoderms, are so obvious that it is only necessary here to allude to their most prominent features, in order to show that they are essentially different in their anatomical structure, though built upon the same plan. In Polyps, the body has the form of a sac, from the inner surface of which project radiating partitions, leaving an open space in the centre, however, which is the main cavity of the body. This central cavity is in free communication with the radiating chambers enclosed between the radiating partitions, for the whole height of the body. In

[1] See Vol. 1 of this work, pp. 137 and 145.

the upper part of the radiating cavity formed by the body-walls arise laterally more or less numerous hollow tentacles, which are also in direct and free communication with the radiating chambers. In fact, the tentacles are simply lateral diverticles of the upper part of the chambers. The centre of the upper part of the sac is widely open, but that opening, generally called the mouth, is not the open edge of the sac; it is the result of the inversion of the upper central part of the body-wall, the outer surface of which, in consequence of this bending inward, becomes internal, and forms what is commonly called the stomach. An accurate idea of this structure may be formed by comparing the sac of a Polyp to a bottle, the neck of which should be turned outside in, and expanded into another sac concentric to the body. This pendent sac, or stomach, is open at the bottom, and this opening leads into the main cavity of the body. The lower opening of the digestive cavity is, therefore, properly speaking, the outer opening of the body-wall, and strictly homologous to the mouth of the Acalephs. The habit of Actiniæ, of turning this so-called stomach inside out, affords an excellent opportunity to trace this homology, when it becomes plain that the opening commonly called mouth in Polyps in no way corresponds to the mouth of the Acalephs. It is equally plain, from such a comparison, that the so-called stomach of the Polyps is not any more homologous to the so-called stomach of the Acalephs. This stomach of the Acalephs can only be homologized with the open space in the centre of the main cavity of the Polyps, with which the radiating chambers stand in the same relation and communication as the radiating tubes of the Acalephs to their so-called stomach. The fluid circulating through the so-called gastero-vascular system of the Acalephs is chyme, and nothing but chyme mixed with water, as I have shown in my contributions to the Natural History of the Acalephs of North America, Part I. page 263.

These facts are in themselves sufficient to distinguish the Polyps under all circumstances, not only from the higher Acalephs, but also from the Hydroids, in which the structure is as essentially Acalephian as in the Medusæ proper. For many years past I have insisted upon these differences, and I truly wonder that there are still naturalists who do not see how completely distinct the structural type of the Polyps is from that of the Acalephs. In my lectures on Comparative Embryology,[1] delivered in the winter of 1848 and 1849, I have already shown, not only how the Hydroids differ from the Polyps, but also how the Hydroids agree

[1] Twelve Lectures on Comparative Embryology, delivered before the Lowell Institute, in Boston, in December and January, 1848–1849, Boston, 1849, 8vo. fig. pp. 42 and 43. See also my paper "On the Structure and Homologies of Radiated Animals, with Reference to the Systematic Position of the Hydroid Polyps," Proc. Amer. Ass. of Sc. Cambridge, 1849, p. 389.

in their structure with the true Medusæ. This agreement is complete; and there is no room left for a distinction between Hydroids and Medusæ, any more than for a reunion of Polyps and Hydroids.

The essential structural peculiarity of the Acalephs, as a class, consists in the presence of a central cavity, hollowed in the mass of the body, without radiating partitions, but with an external central opening, the edge of which is turned outward and more or less prolonged, in the shape of oral appendages or fringes. Tentacular appendages may also exist outside of this central opening, or so-called mouth, or may be wanting; but when they do exist, their cavity, if they are hollow, communicates only indirectly, through radiating tubes, with the main cavity of the body, the radiating tubes themselves uniting with a circular tube that follows the outline of the periphery. This is certainly an essentially different structure from that of the Polyps. Again, while the Polyps are always sexual animals, and frequently hermaphrodites in their adult age, the Hydroids are uniformly destitute of sexual organs, but produce, by budding, an alternate generation, the individuals of which, like ordinary Medusæ, are always, when adult, either male or female. When considering in detail the structure and mode of reproduction of the Acalephs, I shall have occasion fully and conclusively to show that the parts generally considered as generative organs in the Hydroids are truly individual animals, in every way homologous to true Medusæ, and themselves provided with the sexual organs that are wanting in the Hydroids. For the present I must limit myself to the assertion that it is so.

As to the homology between Polyps and Acalephs, it must be apparent, from what precedes, that the comparisons which have been instituted between them are not accurate. If the central opening between the tentacles of the Polyps is not homologous to the so-called mouth of the Acalephs, but simply an aperture arising from such an inversion of the body-wall that the opening at the bottom of the digestive cavity is in reality the external opening of the body, it is plain that the name *mouth* has been applied to very different parts in these animals. It must further appear, that, from the position of this opening and its relation to the whole structure of the animal, the name *mouth* can hardly be applied to it. Indeed, the more we study the lower animals, the more are we impressed with the imperfection of the nomenclature used to designate their parts. To me it now seems quite inappropriate to designate the opening through which the food is introduced into the body by the same name in all animals. Since the study of homologies has become a safe guide in the appreciation of the true nature of the parts of an animal, I can no longer see why we should use the name *mouth* to designate a simple opening in the centre of a radiated structure, when that name was originally applied to a cavity circumscribed by a bony frame, with a muscular apparatus provided with nerves and blood-vessels, and the seat of a special organ of sense. In fact, the Vertebrates alone have a real mouth; and the opening leading to the digestive cavity in other animals is in no way homologous to their mouth, and ought to be called by another name, and by a different name in each type, according to the general homologies of its structure. The so-called mouth of the Articulates is as different from that of the Vertebrates, as it is from that of the Mollusks and that of the Radiates. And if the name *mouth* is to be retained for all, it must be with the distinct understanding that the mouth is essentially different, both in its relations and in its structure, in Radiates, in Mollusks, in Articulates, and in Vertebrates. I do not consider innovations in the nomenclature as favorable to the progress of science, as long as it is possible to convey clear and distinct ideas by the use of ordinary language; but I believe, nevertheless, that a new name, applied to an object long known under another appellation, impresses more forcibly the difference it is intended to express, than a mere qualification of a generally received name. I would, therefore, propose to designate henceforth the mouth of the Radiates by the name of *Actinostome*, that of the Articulates by the name of *Arthrostome*, and that of the Mollusks by the name of *Malacostome*, in allusion to the typical structure of these animals. I shall introduce similar changes in the nomenclature of other parts as often as, in the progress of my exposition, I may have an opportunity of showing, not only the necessity of the change, but also, by a fuller illustration of the homologies of these parts, the propriety of adopting the new name proposed.

The class of Echinoderms is characterized by as different a mode of execution of the plan of structure, involved in the idea of radiation, as the Acalephs and Polyps are; but the plan itself is the same in all. The peculiarity lies in the construction only. The body-wall in Echinoderms forms a radiating cavity, in which are suspended different systems of organs, distinct from the walls themselves, but in various ways connected with them. The ambulacral system, which is homologous to the radiating tubes of the Acalephs and to the radiating chambers of the Polyps, stands in the closest relation to the walls of the body. It traverses them in the form of tubes, radiating from one pole of the body to the other, and emitting, in most of them, external suckers, arranged in rows upon the surface. The alimentary canal, connected with the walls of the body only at the central opening, and, in some, also at the opposite end, extends as a distinct tube or sac, free in the main cavity, and is not circumscribed by the perisome or *spherosome*[1] itself, as in Acalephs. The reproductive apparatus consists also of distinct organs,

[1] I call *spherosome* the body-wall of a radiated animal. I prefer the name of spherosome to that of perisome because that of perisome has already been applied with different meanings.

arranged radiatingly between the ambulacral rows, with which they alternate. This arrangement is strictly homologous to that of the sexual organs of the Polyps and Acalephs; for in Polyps the ovaries and spermaries hang from the edges of the radiating partitions, and in Acalephs they are placed upon the sides of the radiating tubes, or, what amounts to the same, they alternate with the radiating chambers in Polyps and with the radiating tubes in Acalephs, as they alternate with the ambulacral system in Echinoderms. That in Echinoderms the ambulacral system is more or less complicated, assuming now the appearance of gill-like tentacles around the oral aperture in Holothuriæ and Echini, and now that of simple tubes with external suckers, as in most members of this class, does in no way alter the primary organic relations of these parts. The homological identity of the ambulacra of the Echinoderms with the radiating tubes of the Acalephs is most easily ascertained by comparing that system in those Holothuriæ which have no external ambulacral appendages with the disposition of the radiating tubes in the Ctenophoræ. In Synapta, for instance, and in allied genera, the ambulacral system consists of tubes as simple as the radiating tubes of the naked-eyed Medusæ; while in some Beroid Medusæ, such as Bolina, Alcinoë, and Mnemia, the radiating tubes are really more complicated than the ambulacral tubes of Synapta. This apparatus is so strictly homologous in both families, that the Ctenophoræ may fairly be said to possess an ambulacral system identical in its general disposition with that of the lower Holothuriæ. Even the form of some of the Ctenophoræ, such as Beroe proper, Idyia, etc., recalls that of the Holothuriæ.

At the peripheric ends of the ambulacral system of a large number of Echinoderms there are ocelli, which deserve a special notice in this connection. Above each of these ocelli there is frequently an odd ambulacral tube, particularly prominent in some Star-fishes. This odd ambulacral tube bears the same relation to its ocellus as the hollow tentacle of a Sarsia bears to the ocellus at its base; and both have an homologous connection with their respective aquiferous systems. In Sarsia, each hollow tentacle with its ocellus communicates in the same manner with the corresponding radiating tube, as the odd ambulacral tube of a Star-fish with the whole ambulacral system of its ray. When I represent the ambulacral system of the Echinoderms as homologous to the radiating tubes of the Acalephs and to the radiating chambers of the Polyps, I do not overlook the difference there is between them in structure and in functions. But these differences consist in a more or less complicated structure and more or less specialized functions, as we frequently observe even between members of one and the same class and not in a typical modification. Similar differences exist among Echinoderms taken as a class, and even among different families of the same order of that class. In some Star-fishes the digestive cavity is a blind sac, while in others it is open at both ends. So also, in the class of Acalephs, the digestive cavity in most Medusæ is simply hollowed out of the central part of their spherosome, while in Ctenophoræ that cavity has its walls, not only distinct from the spherosome, but in its upper part these walls recede from the mass of the body, and leave an open space between the two, into which the products of digestion are poured. There is, besides, in these animals, a double opening in the upper part of the spherosome, through which the fæcal matters are discharged. Nothing of the kind exists in any other Acaleph. Notwithstanding this, the Ctenophoræ are strictly homologous in all their parts to the other Acalephs. On the other hand, this peculiarity of the digestive cavity of the Ctenophoræ recalls the disposition already noticed in some Star-fishes, and establishes a sort of transition between the extreme modifications in the latter; for, while the digestive sac of some Star-fishes is a closed sac rising into the main cavity of the body without an open communication with it, in other Star-fishes it rises to the upper wall of the body, through which it passes, to open externally, and in Ctenophoræ it opens into the cavity of the body, the walls of which are in their turn pierced with two distinct openings, to afford a passage for the fæces. These two openings cannot be considered as anal openings, since they do not directly communicate with the digestive cavity; nor is the aboral end of the digestive sac to be compared to an anus, for it discharges its contents directly into the main cavity of the body. We have here, throughout, combinations which are entirely foreign to the plan of structure of the other branches of the animal kingdom, and which fully justify what I have already said above respecting the impropriety of calling the parts of these animals by the same names as those of other types. But while the Radiates are thus shown to differ in every respect from the Mollusks, Articulates, and Vertebrates, they at the same time become more and more intimately linked together, in proportion as we are better acquainted with the typical features of their organization.

As to the so-called external skeleton of Echinoderms, it in no way constitutes a peculiarity of this class, in contradistinction to the Acalephs and Polyps; for in Holothuriæ the amount of calcareous deposits is comparatively small and does not affect the flexibility of the spherosome, while the rigidity of the Echini is not greater than that of the Corals compared to Actiniæ. In both it is only a consolidation of the spherosome, resulting from the accumulation of limestone in its tissue; but the actinostome, as well as the diverticles of the aquiferous system, the tentacles and ambulacral suckers, remains soft and movable. To judge correctly of these relations, it is indispensable to observe these animals alive, with all their soft parts fully expanded. In that condition Star-fishes and Sea-urchins have a very different aspect from that which they exhibit when dried up or preserved in alcohol. By comparisons made in this way we are enabled to establish the closest homology between all Radiates, from the Echinoderms down to the Polyps, without losing the connection between their organic systems; nay, even the form and special disposition of certain organs in the two most remote classes of Radiates are intimately linked together by peculiarities characteristic of some of the Acalephs. For instance, the system of radiating tubes in the lower part of the disc of the genuine Medusæ, and still more strikingly in the Rhizostomes and Cassiopeiæ, presents the most striking resemblance to the distribution of the ambulacral tubes in the lower wall of the spherosome in Clypeaster, Scutella, and Echinarachnius; so much so that the difference between the two types is reduced to the difference there is between a soft wall and a solid wall, and that of an ambulacral system with and without external suckers. But since there are Holothuriæ — the Synapta and allied genera — in which these external suckers are wanting, the whole difference amounts only to a different degree of complication in one and the same system, similar to the various degrees of complication observed throughout the animal kingdom in the differentiation of the organs. The comparisons I have been able to make between Cassiopeia and Echinarachnius and Clypeaster are conclusive upon this point, as will be shown in the sequel.

After tracing so close a correspondence and so many connecting links in the structure of the Echinoderms, Acalephs, and Polyps, I may be permitted to ask what there is left to support the idea of a typical difference between the Echinodermata and Cœlenterata, now so generally and so strongly insisted upon by German naturalists. The truth is that the Cœlenterata do not constitute a primary division in the animal kingdom, but must be united with the Echinoderms as members of one and the same type, including three, and only three, natural classes, equally distinct one from the other, — the Polyps, Acalephs, and Echinoderms.[1]

I need hardly remind anatomists of the importance, for their own special studies, attaching to every improvement in the classification of animals; for it is only when their natural affinities are satisfactorily known, that it is possible to give a comprehensive account of their structure.

[1] If this be so, then the name of *Cœlenterata* as designating a distinct type, as well as that of *Anthozoa* as designating the Polyps in contradistinction to the Hydroidea, and that of *Hydromedusina* as including the naked-eyed Medusæ with their polypoid congeners, must be dropped from the system of Zoölogy, and the older names Radiata, Polypi, Acalephæ, and Echinodermata, restored.

SECTION IV.

MORPHOLOGY AND NOMENCLATURE.

Thus far, my aim has been to present an outline of the views entertained by different naturalists upon the various relations among the animals referred to the type of Radiata, taking that group in the widest sense in which it has ever been considered. I have accompanied this survey with incidental critical remarks, and with a few considerations upon the mode of ascertaining the natural limits of a class, and have arrived at the conclusion, that the type of Radiates embraces only three natural classes. This conclusion is founded upon the evidence adduced, that the animals heretofore referred to Radiates, and not belonging to the one or the other of these three classes, are not genuine Radiates, and must therefore be excluded from that type.

I have attempted to show, farther, that the proposed division of Radiates into Cœlenterata and Echinodermata, as distinct primary types, is a mistake arising from an incorrect appreciation of what constitutes respectively a type or branch, and a class, in the animal kingdom. If the views I hold on this subject are true, the Echinoderms, being built upon the same plan as the Polyps and Acalephs, belong to the same type as the so-called Cœlenterata, and constitute only one class of that type. The peculiarities insisted upon as a ground for considering Echinoderms as a distinct type are not differences in the plan of structure, but merely differences in the mode of execution of one and the same plan.

I hold, farther, that the Cœlenterata, as circumscribed by Leuckart, embrace two distinct classes, the essential characters of which are of the same kind as those that separate the Echinoderms from either of them; so that, considering classes to be founded on different ways of carrying out the same structural plan, the type of Radiata should be divided into three classes,—the Polyps, the Acalephs, and the Echinoderms. It is true that the range of structural differences in these classes, within their respective limits, is not always exactly parallel; but it is a fact, too much overlooked by naturalists, that there are very few groups in nature of the same essential value, presenting identical degrees of difference, or even approximating each other in their number of genera and species.

In the regular sequence of my exposition I should now present a sketch of the natural features of the class of Acalephs; but before I make the attempt, a few words upon their morphology and nomenclature are indispensable. This is important, in order that I may be able to present the characteristics of the class with more confidence, and with a clear understanding respecting the true value of the differences noticed between the animals now referred to it, and also that I may point out the various names under which the different parts of these animals have been designated by different authors in their descriptions.

It is much to be regretted that no uniform nomenclature has yet been adopted in describing these animals. Indeed, there are scarcely two authors, among those who have contributed most to build up our knowledge of the Acalephs, who describe their parts under the same name, and this ever-recurring discrepancy is a serious obstacle to an easy perusal of their works. This difficulty has arisen from two causes. First, from a difference of opinion among investigators respecting the real nature of the parts described, and secondly, from a laudable desire to avoid expressing premature opinions upon these structures. Thus, special names were given to any parts in the body of Acalephs that seemed to present characteristic differences, even though these parts might be homological. This conflicting nomenclature has not only made it very difficult to understand the full meaning of the descriptions of Acalephs published by different writers, but has also led to the impression, that the differences among the different families of this class are far greater than is really the case. Such Acalephs, for instance, as have a certain external resemblance to Polyps, as the Hydroids, have been described with the terminology generally applied to Polyps; while the Medusæ proper have been designated by a nomenclature of their own; and the Siphonophoræ in another way still: the latter, indeed, being described in one way by those naturalists who consider them as single animals, and in another way by those who look upon them as communities of combined individuals.

To avoid this complication of nomenclature hereafter, I deem it indispensable to consider not only their relations among themselves, but also their relations to the members of the other classes of the same type. Now, surely, if Acalephs are Radiates, they should bear such a structural relation to the Polyps and Echinoderms, assuming that they belong to the same type, as the Acephala, Gasteropoda, and Cephalopoda, considered as Mollusks, bear to each other; or the Worms, Crustaceans, and Insects considered as Articulates; or the Fishes, Reptiles, Birds, and Mammals considered as Vertebrates. This is so well understood in our days with reference to the Vertebrates and Articulates, and in a measure also with reference to the Mollusks, that no naturalist could consider it as a progress in his science were a new name introduced to designate the webbed hand of a bat or the flapper of a Cetacean, or the rudimentary extremity of the Lizards with imperfect feet, or any other such serial gradation in the development of their different systems of organs. On the contrary, modern naturalists constantly endeavor to simplify the nomenclature of Zoölogy by tracing the homologies of the most diversified parts of the same system. Surely, the head of a fish is not to be called by another name than that of Birds or Mammals, because it is not separated from the chest by a long neck; nor are we to have as many different names as there are different combinations of structure in the parts of the face. The olfactory organ, or the nose, must be called nose or olfactory organ, whether it be as prominent as the proboscis of the elephant, or as blunt as the snout of a fish. The ear must be called ear, be it ever so prolonged externally, or entirely concealed below the surface of the head. All this can be readily done among Vertebrates and among Articulates, because the structure of all these animals is sufficiently well known to force a uniform nomenclature upon the attention of any one who studies them.

The correspondence of the rings of an Articulate, be it a Worm or a Crustacean or an Insect, is evident, whether it be altogether deprived of locomotive appendages, or provided with legs only, or with wings as well as legs; and it will be at once understood, by any one who extends these comparisons sufficiently, that the parts now generally called legs and wings among Insects, though bearing the same names for the present, are not homologous with legs and wings in Vertebrates. The parts of the mouth of a sucking or a chewing Insect, on the contrary, will with the same readiness be recognized as homologous with their so-called legs. Unfortunately, this is not the case with the Radiates. We find almost as many different opinions respecting the parts of Echinoderms, Acalephs, and Polyps, as there are writers on the subject. Even with reference to Echinoderms alone, there are authors who have denied the homology of the solid parts of the Sea-urchins with those of the Star-fishes, and described the solid frame of the one as external, and that of the other as internal.

It is not my intention here to consider the general homologies of the Radiates in detail, as I shall take up the subject again at the end of this monograph. But for the purpose of introducing a more uniform nomenclature among these animals, or, at least, paving the way to it, I will attempt such a general comparison between them as may facilitate a reference of the parts of one class to the parts of another.

The plan upon which the Radiates are built is so peculiar, and so distinct from that of the Mollusks, Articulates, and Vertebrates, that the essential elements of their structure are entirely different. A common Star-fish or a common Sea-urchin is as readily divided into five segments, as a common Medusa into four, or an individual animal of a Gorgonia into eight, or that of an Actinoid Polyp into a larger number, according to different families. Such segments bear to the body as a whole, a relation similar to that observed in the ring of an Insect as one of the essential elements of its structure, or a vertebra with its muscular band

and corresponding pair of nerves and vessels in either Fish, Reptile, Bird, or Mammal, as a segment of the body of a Vertebrate.

Now, it requires no formidable stretch of the imagination to reduce any single Polyp, or any Acaleph or any Echinoderm, to a spheroidal form. Indeed, the sphere is the essential form of all Radiates,—not the mathematical sphere, but the organic sphere, loaded in different directions, according to the peculiarities of the subordinate groups of this type. It has its nearest approach to the sphere in the Echinus; it becomes a cylinder in the Holothuria; it is stellate in the Star-fish; it is bell shaped in the Acaleph; it is trumpet shaped in the Polyp; and in all it has an oral opening in the centre of structure, which may not be the centre of figure.

Keeping in mind this starting point, if we consider the natural position of the animal in its element, we find in Polyps the so-called mouth turned upward in the centre of the broadest expansion of one side of that organic and flexible sphere, while the opposite end, more or less tapering, becomes a base of attachment. Hydroids retain the same attitude, and bear the same general relation to the surrounding medium. Not so with the Medusæ, in which the sphere is freed from all attachment and the oral aperture turned downward, the whole body being more or less hemispheric or bell shaped. In Echinoderms we have not only the Crinoids, recalling, in their relations to the surrounding mediums, the Polyps and Hydroids, but also the Sea-urchins and Star-fishes, in which the mouth is turned downward as in Medusæ, and the Holothurians, in which it is directed forward. In order, therefore, to have a normal position for all Radiates, we must compare them with one another, not in their natural attitudes, but in such a position as would exhibit, in all, the centre of their structure in the same relation to the surrounding medium.

The necessity of thus distinguishing the natural attitude and the normal position of animals is particularly obvious in the study of Radiates. But the distinction is quite as important in other branches of the animal kingdom. Everywhere the possibility of acquiring an insight into the typical structure of any natural group depends primarily upon the position in which its representatives are compared. Had not Rathke taken these relations into consideration, we should not know the antagonism which prevails between the Articulates and Mollusks in their embryonic development. Without keeping them in mind, we shall never be able to homologize the Bryozoa and Tunicata with the other Acephala. Without knowing that an animal may move in a position entirely at variance with the normal position of the other representatives of its class, a description of its characteristic features may appear in direct contradiction to its habits, or mislead us with reference to its natural relation to the surrounding medium. In proportion as we are better acquainted with an animal, the difficulties arising from this discrepancy between natural attitudes and normal positions grow less and less. No one could be misled by a description of a Turbot or a Flounder, representing their structure according to their normal position, even though, in their natural attitude, they lie upon one side; nor would any philosophical observer describe the back of these fishes as lateral on account of their natural attitude. And yet it seems hardly to have occurred to some naturalists, that they make frequently a similar mistake when they describe the lower animals, in almost every group, in a different way; taking everywhere the natural attitude, and not the normal position, as their guide.

It is fitting, that, after alluding to the different attitudes in which the Radiates are found in their natural element, we should attempt to determine what is their normal position. Considering the plan of their structure, we have already seen that there exists in all of them an axis and centre of radiation, around which all their parts are symmetrically arranged in a radiating and concentric order, even though that axis or centre of structure be not the centre of figure or form. At one end of this axis we invariably find the so-called mouth or *actinostome*, while the opposite end of the alimentary canal may have an excentric position. We find, moreover, that in their natural attitude, the actinostome is in all of them turned either upward or downward, with the sole exception of the Holothuriæ, in which it is directed forward. This exception is, moreover, of little importance, since the structural relations of the Holothuriæ to the other Echinoderms leave no doubt as to what is their normal position; and whatever rule we recognize as binding for the other Echinoderms must be followed for the Holothuriæ also.

Once agreed upon this point, there can be no farther doubt, that, in the Radiates, the normal position of the main axis of the body is the vertical, since all, with the single exception of the Holothuriæ, stand in their natural element with that axis in a vertical position. We shall, therefore, not hesitate hereafter to describe the Holothuriæ as if they also were in the habit of standing upright.

It is not quite so easy to determine what should be considered as the upper, and what as the lower, end of the axis. If we look to the Polyps as a guide, we should certainly take the region of the actinostome as the upper end; but if we allow the relations of the higher Radiates to influence us, we should naturally consider the same region as the lower end of the body. It would be incorrect, unquestionably, to assume that the natural attitude of the Holothuriæ is to decide the question, and to describe all the radiated animals with the actinostome forward, as it is evident that the similarity in the natural attitude of the Holothuriæ and Worms is only an analogy, and not a leading feature applicable to the whole type of Radiates. The main axis of the body of these animals is truly vertical; and in this essential relation of their whole structure to the surrounding medium, we have an additional characteristic of this branch, distinguishing it from the three other branches of the animal kingdom. The significance of this upright position of the lowest type of animals with a radiating structure is most striking in view of the upright position of man, at the head of the animal creation.

The same reasons which induce me to discard the indications of the Holothuriæ in determining the normal position of the Radiates, apply to the Medusæ, Star-fishes, and Sea-urchins, when considering which end of the vertical axis should be regarded as the upper and which as the lower. The centre of radiation, as developed in the actinostome, is evidently the prominent feature of the whole organization of this type; it is the climax of the concentration of their structure; upon that side the most sensitive parts of the body are combined; around it the nervous ring with its ganglions is placed, in those representatives of the type in which the differentiation of the tissues goes so far as to lead to the development of a nervous system. It seems natural, therefore, to consider the oral end of the vertical axis as its upper end. But why that end should be turned upwards in the lower Radiates only, I am unable to say: I can only surmise that this position is connected with the immovability of the Polyps, the Hydroids, and the pedunculated Crinoids, and that the advantage they have in that respect over the Medusæ, the Star-fishes, and the Sea-urchins, is a compensation for their inability to move about freely.

Supposing, however, that the actinostome should be considered as the upper end of the vertical axis, it would not be advisable to use the expressions of *upper* and *lower* end or side of the body, in describing the one or the other end of the vertical axis of the Radiates; for, evidently, there would be something unnatural in constantly contrasting the normal position and the natural attitude of the different representatives of this type. I would therefore prefer to apply the name of *actinal* to the side or pole at which the so-called mouth or actinostome is placed, and that of *abactinal* to the opposite side or pole. In this way the description of a Sea-urchin, compared to that of an Actinia, will not involve a seeming contradiction with the attitudes in which these animals are constantly observed in their natural element.

This once fully understood, and assuming that the body of a Radiate, whatever be its real figure and its natural attitudes, may be reduced to a spheroidal form by homological transformations, it is self-evident that the essential segments composing this living sphere will bear to one another identical relations, and as parts of a sphere be homologous to one another, as far as they retain symmetrical relations to the main axis. For these homological segments of the body of Radiates I would propose the name of *Spheromeres*, and, in allusion to the well-known structure of these animals, describe the body of a Holothuria, for instance, or that of an Echinus and a common Star-fish, as consisting of five converging spheromeres, as the body of a Caterpillar or a Butterfly consists of thirteen rings movable upon a longitudinal axis. In most Crinoids we have also five spheromeres, but occasionally four or six, and in some Asterioids even a larger number. In Acalephs the body is generally built of four or eight or twelve spheromeres; but here and there the numbers vary, as we find also that the number of rings varies in the lower Worms. In the Halcyonoid Polyps the number of spheromeres is constantly eight, they being the highest Polyps. In the Actinoids we find, in the lowest families, a large and varying number of spheromeres, sometimes increasing regularly with age; whilst in the highest Actinoids — the Madrepores proper — the individual Polyps are made up of twelve spheromeres, six of which are more prominently developed than the six others. A similar difference between alternating spheromeres is observable among the higher Acalephs. Here unequal spheromeres may combine in such a manner as to produce the appearance of bilateral symmetry; and though this feature is not only common among Radiates, but even prominent in some of the higher representatives in each class of this type, it is yet subordinate to the plan of their structure: for, upon close analysis, it is found, that, even in those Radiates in which bilateral symmetry is most marked, it is in reality the result of a symmetrical arrangement of radiating elements around a vertical axis, and not of elements symmetrically placed upon the two sides of a longitudinal axis.

Thus it appears that the body of all Radiates, be they Polyps, Acalephs, or Echinoderms, is composed of identical elements, which may be called spheromeres; and that these parts are arranged symmetrically around a vertical axis, in the same manner as the wedge-shaped segments of an orange are arranged within its bark. There is no propriety, therefore, in considering the body of Acalephs as something peculiar, and different from that of a Polyp or an Echinoderm, and it is unnecessary to give it a distinct name, as Huxley does, who calls it Hydrosoma, else this name must be extended to all Radiates; for the body of the Actinia is as much a Hydrosoma as that of any Acaleph, and so also is that of Pluteus and allied forms (young Ophiurioids and Echinoids), that of Bipinnaria and Brachiolaria (young Asterioids), and that of Auricularia (young Holothuria). We need, however, distinct names to designate the different stages of development of these animals; which, once sanctioned by use, may become as significant as the names applied to the larval conditions of the Insects.

I should not object to the name of Hydrosoma for the young Acalephs, had we not already, for every stage of their growth, names which are very generally adopted, and which render new ones superfluous. For the earliest state of the embryo Hydroids we have the name of *Planula*, for the Medusæ buds of the Hydroids that of *Pyrulum*, and for the young free Medusæ of the Campanularians that of *Tintinnabulum*, all proposed by Dalyell; for the young of the Discophoræ we may choose between the name of *Hydra*, also proposed by Dalyell, and that of *Scyphistoma*,[1] used by Sars; and for the next stage of their development we have the name of *Strobila*, introduced by Sars and generally adopted. The young free Medusa may best be called *Ephyra*, as that name was first applied to it when it was considered as a distinct genus. If we retain the name Hydra for the sterile animals of the Hydroid type, and that of Scyphostoma for the young Medusa, the name of *Medusa* would be most appropriate for all the adult Medusoids. Our terminology would then be fixed in the following manner: *Planula* would designate the embryonic state of the young Acaleph just hatched from the egg, and moving about by the aid of vibratile cilia; such planulæ are born not only from the eggs of Hydroids, but also from those of Discophoræ, and the young Polyps exhibit the same appearance. The name *Scyphostoma* would apply to the young, from the time it is attached and the tentacles begin to make their appearance. In the Hydroids and Polyps this condition becomes permanent, as the worm-like state of the larvæ of the higher Articulates becomes permanent in the Worms; it is therefore appropriate to retain the name *Hydra* to designate the adult Scyphostoma, which undergoes no further development, and that same name may equally well be used to designate the single individuals in a Hydroid community, as we apply the name Polyps to designate either single Polyps, or single individuals in a Polyp community. The name *Strobila* is so generally used to designate the stage of Scyphostoma in which the vertical axis becomes divided by transverse constrictions, and that of *Ephyra* has so long been applied to the young Medusæ freed from this axis before they assume their final form, that no further argument is needed to sanction their further use. Let it only be remembered, that, as there are Insects with imperfect metamorphosis in which no pupa state is observed, so are there Acalephs in which the larva, overleaping the Strobila segmentation, passes directly from the Scyphostoma to the Ephyra state. This is the case in Pelagia (Pl. XII. *Figs*. 4–11). For the adult Acalephs there can be no more appropriate name than that of *Medusæ*, under which they have always been known. The name of *Pyrulum* for the Medusæ buds of the Hydroids, and that of *Tintinnabulum* for their free Medusæ, are entirely superfluous.

Were all Acalephs simple animals, this nomenclature would be quite sufficient to describe them accurately. But in this class, as among Polyps, there are a great many species in which the individuals combine to form more or less extensive communities; and the Acalephs present this additional peculiarity, that the indi-

[1] This name should be written Scyphostoma, in accordance with its etymology.

viduals of one and the same community are by no means so uniform among themselves as in the class of Polyps. The Acalephian communities are, indeed, generally polymorphous, and cases of great uniformity among their individuals are rare. For these communities we need comprehensive names, as much as for the Polyp communities. Now, just as the name *Polyparium* has been framed to designate a *Polyp community*, we may apply the name of *Hydrarium* to a *community of combined Hydræ*. In this sense, a bunch of Corynæ or of Tubulariæ united by their stems and stolons, a patch of Hydractiniæ rising from their common basis, a branching Campanularia or a Laomedea communicating with others by stolons, or even a single stem with its lateral buds, constitutes *Hydraria*. And so also are Sertulariæ and Plumulariæ genuine *Hydraria*. The same name must also apply to the Siphonophoræ as far as they are communities. But here a distinction is at once suggested, in accordance with the special character of the individuals forming these communities. As long as the combined individuals are all Hydræ, the name Hydrarium correctly applies; but among Siphonophoræ, as among Corynoids and Tubularioids, there arise Medusæ buds from the Hydræ, and these buds are either single, or form by themselves communities of individuals in no way to be distinguished from genuine Medusæ, to which the name of Hydraria cannot be applied, but for which that of *Medusarium* seems very appropriate. I would therefore call *Medusarium* every bunch of Medusæ buds arising from a Hydra, in contradistinction to the single Medusæ buds produced by other kinds of Hydræ. For instance, the Hydræ of a Coryne Hydrarium never produce *Medusaria*, but always single Medusæ buds, while the Hydræ of a Tubularia Hydrarium always produce *Medusaria*. The structural combinations in these animals are so complicated, that, unless we make these distinctions, it will become necessary to resort to long circumlocutions correctly to describe them, and duly to discriminate the true nature of the different kinds of individuals united in one and the same community. It is evident, that a Tubularia community, so long as it produces no Medusæ buds, is simply a Hydrarium; but presently it brings forth Medusæ buds in large clusters, hanging from the single Hydræ in the form of Medusaria, and each Hydra produces several such Medusaria, which are as much parts of the enlarged community as the single Hydræ themselves. By this time the community is no longer a mere Hydrarium, but a Hydrarium bearing Medusaria. It is now a community of heterogeneous communities, which may well be called a *Hydro-Medusarium*.

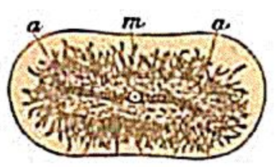
The use of such names for these different communities and their combinations will greatly simplify our descriptions, and add much precision to our characteristics of the different families and genera of the Hydroids. For instance, the *Tubularioids* as a family may be described as *Hydro-Medusaria* arising from single *Hydræ* which by budding and by stolons become *Hydraria;* each adult Hydra producing in time several pendent *Medusaria*. The different genera of the family may then be characterized by the peculiarities of their Hydræ and of their Medusæ. The *Campanularians* as a family may be described as *Hydraria* with two kinds of *Hydræ*: some being sterile and more numerous, while others are fertile and produce Medusæ from their proboscis. The different genera may easily be distinguished by the peculiarities of the two kinds of Hydræ, as well as by their Medusæ. Similar differences exist among the Siphonophoræ. The *Velellidæ* are simply *Hydraria* arising from a single *Hydra* which grows larger and larger until it produces other *Hydræ* of a different form, and from these single Medusæ buds spring forth and finally free themselves. The *Physalidæ*, on the contrary, are *Hydro-Medusaria*, arising, like the Velellidæ, from a single *Hydra*, which also grows larger and larger, and even acquires an enormous size, forming in the end the large swimming-bag, from which single additional Hydræ at first arise, and afterward a larger and larger number, forming several distinct *Hydraria* suspended from the original enlarged Hydra. These Hydraria themselves consist of heterogeneous Hydræ, though of Hydræ only. Others produce *Medusaria*, and thus become *Hydro-Medusaria*; so that a Physalia community is really made up of many heterogeneous communities attached to a gigantic Hydra. The *Diphyidæ* are also *Hydro-Medusaria*, but of a very different kind from those of the Physalidæ. Here the community begins with a medusoid individual, from which arises another Medusa, thus forming Medusæ twins. This twin community produces a string of medusoid Hydroids, from each of which arises another kind of Medusæ, in close connection with their Hydroids, thus forming secondary twin communities, each of which consists of a medusoid Hydra and a genuine Medusa. In the *Physophoridæ*, the combinations are still different. The community constitutes also a *Hydro-Medusarium*; but it arises from a single *Hydra*, from the upper part of which bud sterile *Medusæ*, while other *Hydræ* arise from its lower part, between which, finally, a number of *Medusaria* make their appearance.

As soon as it is conceded that the so-called sexual organs of the Siphonophoræ are themselves individual animals provided with ovaries and spermaries, there is no possibility of avoiding the conclusions presented in the preceding paragraphs respecting the structural constitution of the Acalephs, and the close affinity of the Siphonophoræ and Hydroids proper becomes very striking. For, notwithstanding the extraordinary diversity of the form of these animals, there are, properly speaking, only two kinds of individuals among them: the sterile ones, for which the name *Hydræ* is most appropriate; and the fertile ones, which we may best call *Medusæ*. I must, however, qualify this statement somewhat, in order to avoid every possible misapprehension. There are fertile Hydræ, if the production of buds constitutes fertility, for most Hydræ produce Medusæ buds; but Hydræ are themselves destitute of sexual organs, there being neither males nor females among them; and yet, some of these Hydræ — Hydractinia, for instance — produce only male Medusæ buds, and others only female Medusæ buds, and in this genus the individuals producing either male or female Medusæ buds form distinct communities. Again, not all Medusæ are fertile; for instance, the so-called swimming-bells of the Diphyidæ and Siphonophoræ, though evidently medusoid in their structure, have neither male nor female organs.

After this digression, which was indispensable as an introduction to a critical survey of the prevalent nomenclature of the Acalephs, let us now consider the different names under which the different elements forming the communities of the Siphonophoræ have been described, that we may hereafter more readily compare them with the other members of the class; for the chief difficulty in harmonizing the nomenclature of the Acalephs arises from the complication of the names applied to the Siphonophoræ. In these communities we have at first to distinguish the medusoid and the hydroid individuals, in the same manner as among the Hydroids proper; and, to do this with accuracy, we must recall the comparison already made (p. 50) between Siphonophoræ and Hydroids as compound communities, and remember the prevalence of polymorphism in most of these animals.

The extensive investigations of Leuckart, Vogt, Kölliker, Gegenbauer, and Huxley upon Siphonophoræ, and the many species now known in all their stages of growth, furnish the most welcome materials upon which to base further comparisons. The young Velella, as described and figured by Huxley (Oceanic Hydrozoa, Pl. XI. *Figs.* 9 and 14), is unquestionably a simple genuine Hydra, provided at first with only few tentacles, and in that condition comparable to any single head of a common Hydroid freed from its stem. An adult Velella, on the contrary, is a Hydrarium, that is, a community of secondary Hydræ grown up between the actinostome and the tentacles of the primary Hydra, and from which in due time genuine Medusæ buds arise. The presence of a shield with a crest in the disc or bell of the primary Hydra is only a structural peculiarity of that animal, but not any more altering its true nature and affinities, than the presence of a shell in the mantle of a Gasteropod. The enlarged primary Hydra of the Velella community, when it has become a complicated floating apparatus (*Fig.* 47) from which hang numerous fertile Hydræ, the so-called fertile tentacles, — "gonoblastidial Polypites" of Huxley, "individus reproducteurs" of Vogt, "peripherische Polypen" of Leuckart, "kleine Polypen" of Kölliker (*Fig.* 48), — is still as much a Hydra

Fig. 47.



VELELLA MUTICA, Bosc.
m So-called mouth. — *a a* So-called tentacles. Between the sterile tentacles and the mouth arise the secondary Hydræ, or so-called fertile tentacles, the gonoblastidial Polypites of Huxley.

Fig. 48.

Single so-called fertile tentacle of VELELLA MUTICA, Bosc, Bearing Medusæ buds *d d*. — *a* Base of attachment. — *b* Blunt end of the tentacle, as it appears when the mouth is closed.

as Helix with its shell is an animal of the same order as a Limax with a rudimentary shell, or a Tebennophorus without any shell. Similar differences occur among the Hydroids proper in the genera Coryne, Tubularia, Campanularia, and Sertularia. In Porpita, we observe the same relations between the primary enlarged Hydra with its tentacles and the secondary fertile Hydræ, as in Velella. The polymorphism in these two genera extends only to a marked difference between the primary Hydra and the secondary Hydræ, analogous to the difference there is between the sterile and fertile Hydræ in Campanularia. (Compare *Fig.* 15, p. 46.) Both Velella and Porpita acquire their full size before Medusæ buds appear upon their fertile Hydræ.

In Physalia, the community is also formed upon an enlarged primary Hydra. The young of this genus has been described and figured by Huxley in two different stages of growth (Oceanic Hydrozoa, Pl. X. *Figs.* 1 and 2). In the earliest stage it is a simple Hydra with a single tentacle (*Fig.* 1); and while that primary Hydra is enlarging and assuming its permanent characteristics, other secondary Hydræ, somewhat different from the first, bud forth from it, and form with it a Hydrarium (*Fig.* 2), gradually enlarging by the addition of others. But there is this difference between such a Physalia Hydrarium and a Velella Hydrarium, that in the former the successive secondary Hydræ differ among themselves greatly,—some acquiring a considerable size and having a large tentacle, while others remain small and have a small tentacle, and the proboscis of some having an open mouth, while in others it remains closed. But, as I shall show hereafter, similar differences are also observed among the Hydroids proper: so that the peculiarities noticed in the different Hydræ amount only to a more extensive polymorphism in this genus than in Velella and Porpita, akin to what we have already seen in Hydractinia. As I myself have seen a great many small Physaliæ in the Gulf of Mexico, I may add that these communities acquire a considerable size before any other but Hydræ buds are developed from their pendent bunches. But when about one fourth the size (*Fig.* 49) of the largest I have ever seen, the Medusæ buds begin to make their appearance and increase in number, until they form distinct Medusaria combined with Hydraria; and the whole community is then a most complicated Hydro-Medusarium. The androphores and gynophores of such a community

Fig. 49.

PHYSALIA ARETHUSA, Til.

a Blunt end of the air sac, supporting the whole community, at which the youngest Medusæ buds may be found.—*b* Open end of the air sac, the mouth of the primary Hydra.—*c* Crest of the air sac.—*m* Bunches of single individuals; and among them the youngest Medusæ buds.—*n* Contracted tentacle.—*t t* Tentacles of the largest kind extended.

are respectively the male and female Medusæ; and buds of both sexes arise from one and the same Hydra, the so-called gonoblastidium.

In Physophoridæ also, the community begins with a single Hydra. Leuckart (Zoologische Untersuchungen, I. Pl. 2, *Fig.* 23), Kölliker (Schwimmpolypen von Messina, Pl. II. *Fig.* 11), Vogt (Siphonophores de la mer de Nice, Pl. VI. *Fig.* 24; Pl. X. *Figs.* 32 and 35; and Pl. XI.), Gegenbauer (Beiträge, etc., in Zeitsch. f. wiss. Zool. vol. 5, Pl. XVII. *Figs.* 7, 8, 9, and 11), and Huxley (Oceanic Hydrozoa, Pl. VI. *Fig.* 12, and Pl. VIII. *Fig.* 2), have described and figured many such young Physophoridæ, exhibiting the primary Hydræ of different genera more or less free from the secondary productions budding from their sides. In the youngest of them the Hydra character is quite plain, and their resemblance to the young Physalia most striking (*Fig.* 50). But their resemblance to the Hydroid of Nemopsis Gibbesii *McCrady* is still more important, since it shows, beyond the possibility of a doubt, the close affinity of the naked-eyed Medusæ and the Siphonophoræ. Thus far, all the Medusæ known as originating from Hydroids had been observed to bud from Hydroids attached by their basis; but, in a recent paper (Gymnophthalmata of Charleston harbor, published in the Proceedings of the Elliott Society of Nat. Hist. for 1858), Mr. McCrady has described a species of Nemopsis, which originates from a floating, locomotive Hydroid, so similar to a young Physophora with incipient buds of swimming-bells, that, had he not traced the connection of the free Medusa to its Hydroid, or had the Hydroid alone, with its young Medusæ buds, been observed, it would unquestionably have been considered as a distinct genus belonging to the Siphonophoræ. A more direct proof that the so-called swimming-bells (Nectocalyces) of the Physophoridæ are genuine Medusæ buds remaining connected with the elongated axis of the primary Hydra (the Coenosarc) from which they grow, cannot be desired. And the only marked generic difference between Nemopsis and Physophora consists in the presence of tentacles and sexual organs in the Medusæ of the former which become free, while those of the latter are sterile and remain attached. But such differences are not essential among animals in which polymorphism occurs so extensively as in the lower Acalephs.

Fig. 50.

YOUNG PHYSOPHORA,
(*Copied from Gegenbauer.*)
c Buds of so-called swimming-bells. — *b b* So-called tentacles; lower *b* so-called Polyp. — *c c* Feelers with lasso cells. — *r* Air sac. — *r*, lower *b*, and *c*, the primary Hydra; *b* and *b* secondary Hydræ; *c* the Medusæ buds.

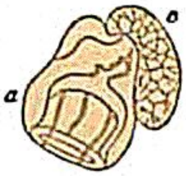
Very early the single Hydræ, from which arise the communities of Physophoridæ, bring forth two kinds of buds, — Medusæ buds on their abactinal pole, and Hydræ buds on their actinal pole. Thus the community at once becomes a Hydro-Medusarium, consisting of one kind of Medusæ which remain sterile and never free themselves, and of two kinds of Hydræ; namely, the primary Hydra, which is gradually enlarged and elongated and from which hang all the other secondary buds, and the secondary Hydræ, which are more or less similar to one another and remain small through life.

The next step in the complication of these communities consists in the appearance of other kinds of Medusæ and other kinds of Hydroids, variously combined in different genera: the additional Medusæ being genuine sexual Medusæ, and the additional Hydroids partaking also, more or less, of the character of Medusæ. A comparison of these sexual Medusæ buds of Siphonophoræ with the Medusæ buds of ordinary Hydroids must satisfy any one, equally familiar with the mode of development of the two types, that there is no essential difference between them. The illustrations published by Kölliker in the "Schwimmpolypen" (Pl. VIII. *Figs.* 4 and 5) afford the best example on record for a comparison with *Figs.* 13, 14, 15, and 16 of Pl. XVIII. of this work. *Fig.* 4 of Kölliker represents what he calls the testis of Vogtia pentacantha; it is the exact counterpart of my *Figs.* 13 and 14, which represent a male Medusa of Coryne mirabilis. Kölliker's *Fig.* 5 represents what he calls the ovary of the Vogtia; it corresponds exactly to my *Figs.* 15 and 16, which represent the female Medusa of Coryne. Now this so-called testis and this so-called ovary consist of a genuine Medusa bell, with four radiating chymiferous tubes and a circular tube, identical in their structure and arrangement with the chymiferous tubes of all the naked-eyed Medusæ. The resemblance extends even further: Kölliker's *Fig.* 4 shows distinctly the proboscis of this supposed testis; it is marked *c* in his figure and described as sperm sac, and its vibratile cavity is marked *d*. The proboscis of the supposed ovary is not less distinct in *Fig.* 5; it is marked *c*, and described as an egg sac. But had Kölliker examined more fully these prominent sacs arising from the centre of their Medusæ bells, he would have satisfied himself that the sperm cells and the eggs are not contained in the cavity of the sacs, but arise, as the eggs and sperm cells of the Coryne, in the outer wall of the sacs; that is, upon the proboscis of the Medusæ, as in Coryne and a large number of other genera of naked-eyed Medusæ.

The second kind of secondary Hydræ, upon the actinal prolongation of the axis of the primary Hydra of many Physophoridæ, differs from those already described in having a so-called covering scale (Deckblatt, Hydrophyllium) by the side of their pendent proboscis. As I have already shown (pp. 54 to 56), this is a kind of open bell, intermediate in its character between the calyx of an ordinary Hydroid and the bell of an ordinary Medusa, more medusoid than the calyx of a Hydroid but less so than a Medusa proper, having no radiating chymiferous tubes, and differing from both in being one sided and more or less flattened. But as one-sided calyces occur also among Hydroids, this does not constitute an important difference, nor a distinguishing feature for Siphonophoræ.

It has already been stated, that the communities of Diphyidæ[1] begin with a Medusa (*Fig.* 51), judging from the investigations of Gegenbauer detailed above

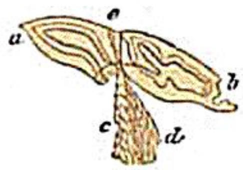
Fig. 51.



Embryo of
DIPHYES SIEBOLDII, Köll.
(*Copied from Gegenbauer.*)

e Remnant of the embryonal body. — *a* Swimming-bell developed from the embryonal body.

Fig. 52.



GALEOLARIA FILIFORMIS, Leuck.
Diphyes quadrivalvis, Gegenb.
(*Copied from Gegenbauer.*)

a b Anterior and posterior swimming-bells. — *c* String of twin individuals. — *d* Feelers with lasso cells. — *e* Cæcal termination or base of the connecting tube or axis of the community.

Fig. 53.

Two twin individuals of the pendent string of the community of
DIPHYES SIEBOLDII, Köll.

a a The so-called scales. — *b b* The so-called Polyps. — *m* The so-called sexual capsule. — *c* External feeler, with lasso cells. — *d* Feeler contracted.

(pp. 53 and 54), and that from the first twin community, formed of two sterile Medusæ (*Fig.* 52 *a b*), arise a string of similar twin communities (*Fig.* 52 *c*), consisting of a medusoid Hydra (*Fig.* 53 *a a*) and a fertile sexual Medusa (*Fig.* 53 *m*), the so-called Gonocalyx, dropping off together and living for a time as independent beings, several of which have been described as distinct genera.

If the views I have here presented of the nature of the Siphonophoræ are correct, there is no need of a special nomenclature to describe the different individuals of their communities; and we shall hereafter deal with them as with different kinds of Hydræ and of Medusæ, describing successively their polymorphous individuals as we would describe different genera and species of Hydroids and of free Acalephs belonging to other families of the class, and introduce only one new element in these descriptions, on account of the different modes of association of the many individuals united together in one and the same community, as it becomes necessary here to allude to their various combinations.

[1] Since the preceding pages were printed I have received two interesting papers upon Diphyidæ and Physophoridæ from their distinguished author, Dr. C. Gegenbauer: Ueber Abyla trigona und deren Eudoxiernbrut, Jena, 4to. fig.; and Neue Beiträge zur nähern Kenntniss der Siphonophoren; separately printed from the Act. Nov. Acad. Natur. Curios. for the current year.

SECTION V.

INDIVIDUALITY AND SPECIFIC DIFFERENCES AMONG ACALEPHS.

The morphological phenomena discussed in the preceding section naturally lead to a consideration of individuality, and of the extent and importance of specific differences among the Acalephs. A few years ago the prevailing opinion among naturalists was, that, while genera, families, orders, classes, and any other more or less comprehensive division among animals, were artificial devices of science to facilitate our studies, species alone had a real existence in nature. Whether the views I have presented in the first volume of this work (p. 163), where I showed that species do not exist in any different sense from genera, families, etc., etc., had any thing to do with the change which seems to have been brought about upon this point among scientific men, is not for me to say. But, whatever be the cause, it is certainly true, that, at the present day, the number of naturalists who deny the real existence of species is greatly increased.

Darwin, in his recent work on the "Origin of Species,"[1] has also done much to shake the belief in the real existence of species; but the views he advocates are entirely at variance with those I have attempted to establish. For many years past I have lost no opportunity to urge the idea, that while species have no material existence, they yet exist as categories of thought, in the same way as genera, families, orders, classes, and branches of the animal kingdom. Darwin's fundamental idea, on the contrary, is, that species, genera, families, orders, classes, and any other kind of more or less comprehensive divisions among animals, do not exist at all, and are altogether artificial, differing from one another only in degree, all having originated from a successive differentiation of a primordial organic form, undergoing successively such changes as would at first produce a variety of species; then genera, as the difference became more extensive and deeper; then families, as the gap widened still farther between the groups; until, in the end, all that diversity was produced which has existed or which now exists. Far from agreeing with these views, I have, on the contrary, taken the ground that all the natural divisions in the animal kingdom are primarily distinct, founded upon different categories of characters, and that all exist in the same way, that is, as categories of thought embodied in individual living forms. I have attempted

[1] DARWIN (CHARLES), On the Origin of Species by means of Natural Selection, or the Preservation of favored Races in the Struggle for Life, London, 1860, 1 vol. 8vo.

to show that branches in the animal kingdom are founded upon different plans of structure, and for that very reason have embraced from the beginning representatives between which there could be no community of origin; that classes are founded upon different modes of execution of these plans, and therefore they also embrace representatives which could have no community of origin; that orders represent the different degrees of complication in the mode of execution of each class, and therefore embrace representatives that could not have a community of origin any more than the members of different classes or branches; that families are founded upon different patterns of form, and embrace representatives equally independent in their origin; that genera are founded upon ultimate peculiarities of structure, embracing representatives, which, from the very nature of their peculiarities, could have no community of origin; and that, finally, species are based upon relations and proportions that exclude, as much as all the preceding distinctions, the idea of a common descent.

As the community of characters among the beings belonging to these different categories arises from the intellectual connection which shows them to be categories of thought, they cannot be the result of a gradual material differentiation of the objects themselves. The argument on which these views are founded may be summed up in the following few words: species, genera, families, etc., exist as thoughts; individuals, as facts. It is presented at full length in the first volume of this work (pp. 137–168), where I have shown that individuals alone have a definite material existence, and that they are for the time being the bearers, not only of specific characteristics, but of all the natural features in which animal life is displayed in all its diversity; individuality being, in fact, the great mystery of organic life.

Since the arguments presented by Darwin in favor of a universal derivation, from one primary form, of all the peculiarities existing now among living beings, have not made the slightest impression on my mind, or modified in any way the views I have already propounded, I may fairly refer the reader to the paragraphs alluded to above as containing sufficient evidence of their correctness; and I will here only add a single argument, which seems to leave the question where I have placed it. Had Darwin or his followers furnished a single fact to show that individuals change, in the course of time, in such a manner as to produce, at last, species different from those known before, the state of the case might be different.[1] But it stands recorded now as before, that the animals known to the

[1] It seems to me that there is much confusion of ideas in the general statement, of the variability of species, so often repeated of late. If species do not exist at all, as the supporters of the transmutation theory maintain, how can they vary? And if individuals alone exist, how can the differences

ancients are still in existence, exhibiting to this day the characters they exhibited of old. The geological record, even with all its imperfections exaggerated to distortion, tells now, what it has told from the beginning, that the supposed intermediate forms between the species of different geological periods are imaginary beings, called up merely in support of a fanciful theory. The origin of all the diversity among living beings remains a mystery, as totally unexplained as if the book of Darwin had never been written; for no theory, unsupported by fact, however plausible it may appear, can be admitted in science.[1]

which may be observed among them prove the variability of species? The fact seems to me to be, that, while species are based upon definite relations among individuals, which differ in various ways among themselves, each individual, as a distinct being, has a definite course to run from the time of its first formation to the end of its existence, during which it never loses its identity nor changes its individuality, nor its relations to other individuals belonging to the same species, but preserves all the categories of relationship which constitute specific or generic or family affinity, or any other kind or degree of affinity. *To prove that species vary, it should be proved that individuals, born from common ancestors, change the different categories of relationship which they bore primitively to one another;* while all that has thus far been shown is, that there exists a considerable difference among individuals of one and the same species. This may be new to those who have looked upon every individual picked up at random, as affording the means of describing satisfactorily any species; but no naturalist who has studied carefully any of the species now best known, can have failed to perceive that it requires extensive series of specimens accurately to describe a species, and that the more complete such series are, the more precise appear the limits which separate species. Surely the aim of science cannot be to furnish amateur zoölogists or collectors a *recipe* for a ready identification of any chance specimen that may fall into their hands. And the difficulties with which we may meet in attempting to characterize species do not afford the first indication that species do not exist at all, as long as most of them can be distinguished, as such, almost at first sight. I foresee that some convert to the transmutation creed will at once object, that the facility with which species may be distinguished is no evidence that they were not derived from other species. It may be so. But, as long as no fact is adduced to show that any one well-known species among the many thousands that are buried in the whole series of fossiliferous rocks is actually the parent of any one of the species now living, such arguments can have no weight; and thus far the supporters of the transmutation theory have failed to produce any such facts. Instead of facts, we are treated with marvellous bear, cuckoo, and other stories. Credat Judæus Apella!

[1] It seems generally admitted, that the work of Darwin is particularly remarkable for the fairness with which he presents the facts adverse to his views. It may be so; but I confess that it has made a very different impression upon me. I have been more forcibly struck with his inability to perceive when the facts are fatal to his argument, than with any thing else in the whole work. His chapter on the Geological Record, in particular, appears to me to be, from beginning to end, a series of illogical deductions and misrepresentations of the modern results of Geology and Palæontology. I do not intend to argue here, one by one, the questions he has discussed. Such arguments end too often in special pleading; and any one familiar with the subject may readily perceive where the truth lies, by confronting his assertions with the geological record itself. But, since the question at issue is chiefly to be settled by palæontological evidence, and I have devoted the greater part of my life to the special study of the fossils, I wish to record my protest against his mode

It would be out of place to discuss here in detail the arguments by which Darwin attempts to explain the diversity among animals. Suffice it to say

of treating this part of the subject. Not only does Darwin never perceive when the facts are fatal to his views, but, when he has succeeded by an ingenious circumlocution in overleaping the facts, he would have us believe that he has lessened their importance, or changed their meaning. He would thus have us believe that there have been periods during which all that had taken place during other periods was destroyed; and this solely to explain the absence of intermediate forms between the fossils found in successive deposits, for the origin of which he looks to those missing links, whilst every recent progress in Geology shows more and more fully how gradual and successive all the deposits have been which form the crust of our earth. — He would have us believe that entire faunæ have disappeared before those were preserved, the remains of which are found in the lowest fossiliferous strata; when we find everywhere non-fossiliferous strata below those that contain the oldest fossils now known. It is true, he explains their absence by the supposition that they were too delicate to be preserved; but any animals from which Crinoids, Brachiopods, Cephalopods, and Trilobites could arise, must have been similar enough to them to have left, at least, traces of their presence in the lowest non-fossiliferous rocks, had they ever existed at all. — He would have us believe that the oldest organisms that existed were simple cells, or something like the lowest living beings now in existence; when such highly organized animals as Trilobites and Orthoceratites are among the oldest known. — He would have us believe that these lowest first born became extinct, in consequence of the gradual advantage some of their more favored descendants gained over the majority of their predecessors; when there exist now, and have existed at all periods in past times, as large a proportion of more simply organized beings, as of more favored types; and when such types as Lingula were among the lowest Silurian fossils, and are alive at the present day. — He would have us believe that each new species originated in consequence of some slight change in those that preceded; when every geological formation teems with types that did not exist before. — He would have us believe that animals and plants became gradually more and more numerous; when most species appear in myriads of individuals, in the first bed in which they are found. — He would have us believe that animals disappear gradually; when they are as common in the uppermost bed in which they occur, as in the lowest, or any intermediate bed. Species appear suddenly and disappear suddenly in successive strata. That is the fact proclaimed by Palæontology; they neither increase successively in number, nor do they gradually dwindle down; none of the fossil remains thus far observed show signs of a gradual improvement or of a slow decay. — He would have us believe that geological deposits took place during periods of subsidence; when it can be proved that the whole continent of North America is formed of beds which were deposited during a series of successive upheavals. I quote North America in preference to any other part of the world, because the evidence is so complete here that it can be overlooked only by those who may mistake subsidence for the general shrinking of the earth's surface, in consequence of the cooling of its mass. In this part of the globe, fossils are as common along the successive shores of the rising deposits of the Silurian system, as anywhere along our beaches; and each of these successive shores extends from the Atlantic States to the foot of the Rocky Mountains. The evidence goes even further; each of these successive sets of beds of the Silurian system contains peculiar fossils, neither found in the beds above nor in the beds below, and between them there are no intermediate forms. And yet Darwin affirms that "the littoral and sub-littoral deposits are continually worn away, as soon as they are brought up by the slow and gradual rising of the land within the grinding action of the coast waves." Origin of Species, p. 290. — He would also have us believe that he has lost sight of the most striking of the features, and the one which pervades the whole, namely, that there runs throughout nature unmistakable evidence of thought, corresponding to the mental operations of our own mind, and therefore intelligible to us as thinking beings, and unaccountable on any other basis than that they owe their existence to the working of intelligence; and no theory that overlooks this element can be true to nature.[1] It is true, Darwin

that the most perfect organs of the body of animals are the product of gradual improvement; when eyes as perfect as those of the Trilobites are preserved with the remains of these oldest animals.— He would have us believe that it required millions of years to effect any one of these changes; when far more extraordinary transformations are daily going on, under our eyes, in the shortest periods of time, during the growth of animals.— He would have us believe that animals acquire their instincts gradually; when even those that never see their parents, perform at birth the same acts, in the same way, as their progenitors.— He would have us believe that the geographical distribution of animals is the result of accidental transfers; when most species are so narrowly confined within the limits of their natural range, that even slight changes in their external relations may cause their death. And all these, and many other calls upon our credulity, are coolly made in the face of an amount of precise information, readily accessible, which would overwhelm any one who does not place his opinions above the records of an age eminently characterized for its industry; and during which, that information was laboriously accumulated by crowds of faithful laborers.

[1] There are naturalists who seem to look upon the idea of creation — that is, a manifestation of an intellectual power by material means — as a kind of bigotry; forgetting, no doubt, that whenever they carry out a thought of their own, they do something akin to creating; unless they look upon their own elucubrations as something in which their individuality is not concerned, but arising without an intervention of their mind, in consequence of the working of some "bundles of forces," about which they know nothing themselves. And yet such men are ready to admit that matter is omnipotent, and consider a disbelief in the omnipotence of matter tantamount to imbecility: for, what is the assumed power of matter to produce all finite beings, but omnipotence? And what the outcry raised against those who cannot admit it, but an insinuation that they are *non compos?* The book of Mr. Darwin is free of all such uncharitable sentiments towards his fellow-laborers in the field of science; nevertheless, his mistake lies in a similar assumption that the most complicated system of combined thoughts can be the result of accidental causes: for he ought to know, as every physicist will concede, that all the influences to which he would ascribe the origin of species are accidental in their very nature; and he must know, as every naturalist familiar with the modern progress of science does know, that the organized beings which live now, and have lived in former geological periods, constitute an organic whole, intelligibly and methodically combined in all its parts. As a zoölogist he must know, in particular, that the animal kingdom is built upon four different plans of structure; and that the reproduction and growth of animals take place according to four different modes of development; and that, unless it is shown that these four plans of structure and these four modes of development are transmutable one into the other, no transmutation theory can account for the origin of species. The fallacy of Darwin's theory of the origin of species by means of natural selection may be traced in the first few pages of his book, where he overlooks the difference between the voluntary and deliberate acts of selection applied methodically by man to the breeding of domesticated animals and the growing of cultivated plants, and the chance influences which may affect animals and plants in a state of

states that the close affinity existing among animals can only be explained by a community of descent, and he goes so far as to represent these affinities as evidence of such a genealogical relationship; but I apprehend that the meaning of the words he uses has misled him into the belief that he had found the clue to phenomena which he does not even seem correctly to understand. There is nothing parallel between the relations of animals belonging to the same genus or the same family, and the relations between the progeny of common ancestors. In the one case we have the result of a physiological law regulating reproduction, and in the other, affinities which no observation has thus far shown to be in any way connected with reproduction. The most closely allied species of the same genus or the different species of closely allied genera, or the different genera of one and the same natural family, embrace representatives, which, at some period or other of their growth, resemble one another more closely than the nearest blood relations; and yet we know that they are only stages of development of different species distinct from one another at every period of their life. The embryo of our common fresh-water turtle (*Chrysemis picta*) and the embryo of our snapping turtle (*Chelydra serpentina*) resemble one another far more than the different species of Chrysemis in their adult state; and yet not a single fact can be adduced to show that any one egg of an animal has ever produced an individual of any species but its own. A young snake resembles a young turtle or a young bird much more than any two species of snakes resemble one another; and yet they go on reproducing their kinds, and nothing but their kinds. So that no degree of affinity, however close, can, in the present state of our science, be urged as

nature. To call these influences "natural selection," is a misnomer which will not alter the conditions under which they may produce the desired results. Selection implies design; the powers to which Darwin refers the origin of species can design nothing. Selection is no doubt the essential principle on which the raising of breeds is founded; and the subject of breeds is presented in its true light by Darwin: but this process of raising breeds by the selection of favorable subjects is in no way similar to that which regulates specific differences. Nothing is more remote from the truth than the attempted parallelism between the breeds of domesticated animals and the species of wild ones. Did there exist such a parallelism as Darwin maintains, the differences among the domesticated breeds should be akin to the differences among wild species; and afford a clue to determine their relative degree of affinity by a comparison with the pedigrees of well-known domesticated races. Again, if there were any such parallelism, the distinctive characteristics of different breeds should be akin to the differences which exist between fossil species of earlier periods, and those of the same genera now living. Now, let any one familiar with the fossil species of the the genera Bos and Canis compare them with the races of our dogs and of our cattle, and he will find no correspondence whatever between them; for the simple reason, that they do not owe their existence to the same causes. It must therefore be distinctly stated, that Darwin has failed to establish a connection between the mode of raising domesticated breeds and the cause or causes to which wild animals owe their specific differences.

exhibiting any evidence of community of descent; while the power that imparted all their peculiarities to the primitive eggs of all the species now living side by side, could also impart similar peculiarities with similar relations, and all degrees of relationship, to any number of other species that have existed previously. Until, therefore, it can be shown that any one species has the ability to delegate such specified peculiarities and relations to any other species or set of species, it is not logical to assume that such a power is inherent in any animal, or that it constitutes part of its nature.[1] We must look to the original power that imparted life to the first being for the origin of all other beings, however mysterious and inaccessible the modes by which all this diversity has been produced, may remain for us. A plausible explanation is no explanation at all, if it does not cover the whole ground.[2]

[1] The difficulty of ascertaining the natural limits of some species, and the mistakes made by naturalists when describing individual peculiarities as specific, have nothing to do with the question of the origin of species; and yet, Darwin places great weight, in support of his theory, upon the differences which exist among naturalists in their views of species. Some of the metals are difficult to distinguish, and have frequently been mistaken, and the specific differences of some may be questioned: but what could that have to do with the question of the origin of metals, in the minds of those who may doubt the original difference of metals? Nothing more than the blunders of some naturalists, in identifying species, with the origin of species of animals and plants. The great mischief in our science now lies in the self-complacent confidence with which certain zoölogists look upon a few insignificant lines, called diagnoses, which they have the presumption to offer as characteristics of species, or, what is still worse, as checks upon others to secure to themselves a nominal priority. Such a treatment of scientific subjects is unworthy of our age.

[2] All the attempts to explain the origin of species may be brought under two categories: some naturalists admitting that all organized beings are created (that is to say, endowed from the beginning of their existence with all their characteristics), while others assume that they arise spontaneously. This classification of the different theories of the origin of species may appear objectionable to the supporters of the transmutation theory; but I can perceive no essential difference between their views and the old idea that animals may have arisen spontaneously. They differ only in the modes by which the spontaneous appearance is assumed to be effected. Some believe that physical agents may so influence organized beings as to modify them; this is the view of DeMaillet, and the Vestiges of Creation: others believe that the organized beings themselves change in consequence of their own acts, by changing their mode of life, etc.: this is the view of Lamarck: others still assume that animals and plants tend necessarily to improve, in consequence of the struggle for life, in which the favored races are supposed to survive; this is the view lately propounded by Darwin. I believe these theories will, in the end, all share the fate of the theory of spontaneous generations, so called, as the facts of nature shall be confronted more closely with the theoretical assumptions. The theories of De-Maillet, Oken, and Lamarck, are already abandoned by all those who have adopted the transmutation theory of Darwin; and unless Darwin and his followers succeed in showing that the struggle for life tends to something beyond favoring the existence of certain individuals over that of other individuals, they will soon find that they are following a shadow. The assertion of Darwin, which has crept into the title of his work, is, that favored

Whatever views are correct concerning the origin of species, one thing is certain, that as long as they exist they continue to produce, generation after generation, individuals which differ from one another only in such peculiarities as relate to their individuality. The great defect in Darwin's treatment of the subject of species lies in the total absence of any statement respecting the features that constitute individuality. Surely, if individuals may vary within the limits assumed by Darwin, he was bound first to show that individuality does not consist of a sum of hereditary characteristics, combined with variable elements, not necessarily transmitted in their integrity, but only of variable elements. That the latter is not the case, stands recorded in every accurate monograph of all the types of the animal kingdom upon which minute embryological investigations have been made. It is known that every individual egg undergoes a series of definite changes before it reaches its mature condition; that every germ formed in the egg passes through a series of metamorphoses before it assumes the structural features of the adult; that in this development the differences of sex may very early become distinct; and that all this is accomplished in a comparatively very short time,—extremely short, indeed, in comparison to the immeasurable periods required by Darwin's theory to produce any change among species; and yet all this takes place without any deviation from the original type of the species, though under circumstances which would seem most unfavorable to the maintenance of the type. Whatever minor differences may exist between the products of this succession of generations are all *individual peculiarities*, in no way connected with the essential features of the species, and therefore as

races are preserved; while all his facts go only to substantiate the assertion that favored *individuals* have a better chance in the struggle for life than others. But who has ever overlooked the fact that myriads of individuals of every species constantly die before coming to maturity? What ought to be shown, if the transmutation theory is to stand, is, that these favored individuals diverge from their specific type; and neither Darwin nor anybody else has furnished a single fact to show that they go on diverging. The criterion of a true theory consists in the facility with which it accounts for facts accumulated in the course of long-continued investigations, and for which the existing theories afforded no explanation. It cannot, certainly, be said that Darwin's theory will stand by that test. It would be easy to invent other theories that might account for the diversity of species quite as well, if not better, than Darwin's preservation of favored races. The difficulty would only be to prove that they agree with the facts of nature. It might be assumed, for instance, that any one primary being contained the possibilities of all those that have followed, in the same manner as the egg of any animal possesses all the elements of the full-grown individual; but this would only remove the difficulty one step further back. It would tell us nothing about the nature of the operation by which the change is introduced. Since the knowledge we now have, that similar metamorphoses go on in the eggs of all living beings, has not yet put us on the track of the forces by which the changes they undergo are brought about, it is not likely that by mere guesses we shall arrive at any satisfactory explanation of the very origin of these beings themselves.

transient as the individuals; while the specific characters are for ever fixed. A single example will prove this. All the robins of North America now living have been for a short time in existence; not one of them was alive a century ago, when Linnæus for the first time made known that species, under the name of Turdus migratorius, and not one of the specimens observed by Linnæus and his contemporaries was alive when the pilgrims of the Mayflower first set foot upon the rock of Plymouth. Where was the species at these different periods, and where is it now? Certainly nowhere but in the individuals alive for the time being; but not in any single one of them, for that one must be either a male or a female, and not the species; not in a pair of them, for the species exhibits its peculiarities in its mode of breeding, in its nest, in its eggs, in its young, as much as in the appearance of the adult; not in all the individuals of any particular district, for the geographical distribution of a species over its whole area forms also part of its specific characters.[1] A species is only known when its whole history has been ascertained, and that history is recorded in the life of individuals through successive generations. The same kind of argument might be adduced from every existing species, and with still greater force, by a reference to those species already known to the ancients.

Let it not be objected, that the individuals of successive generations have presented marked differences among themselves; for these differences, with all the monstrosities that may have occurred during these countless generations, have passed away with the individuals as individual peculiarities, and the specific characteristics alone have been preserved, together with all that distinguishes the genus, the family, the order, the class, and the branch to which the individual belonged. And all this has been maintained through a succession of repeated changes, amounting in each individual to the whole range of transformations through which an individual passes, from the time it is individualized as an egg to the time it is itself capable of reproducing its kind, and, perhaps, with all the intervening phases of an unequal production of males and females, of sterile individuals, of dwarfs, of giants, etc., etc., during which there were millions of chances for a deviation from the type. Does this not prove, that, while individuals are perishable, they transmit, generation after generation, all that is specific or generic, or, in one word, *typical* in them, to the exclusion of every *individual peculiarity*, which

[1] We are so much accustomed to see animals reproducing themselves generation after generation, that the fact no longer attracts our attention, and the mystery involved in it no longer excites our admiration. But there is certainly no more marvellous law in all nature than that which regulates this regular succession. And upon this law the maintenance of species depends; for observation teaches us that all that is not individual peculiarity is unceasingly and integrally reproduced, while all that constitutes individuality, as such, constantly disappears.

passes away with them; and that, therefore, while individuals alone have a material existence, species, genera, families, orders, classes, and branches of the animal kingdom, exist only as categories of thought in the Supreme Intelligence, and, as such, have as truly an independent existence, and are as unvarying, as thought itself after it has once been expressed.

Returning, after this digression, to the question of individuality among Acalephs, we meet here phenomena far more complicated than among higher animals. Individuality, as far as it depends upon material isolation, is complete and absolute in all the higher animals, and there maintained by genetic transmission, generation after generation. Individuality, in that sense, exists only in comparatively few of the Radiates. Among Acalephs it is ascertained only for the Ctenophoræ and some Discophoræ. In others, the individuals born from eggs end by dividing into a number of distinct individuals. In others still, the successive individuals derived from a primary one remain connected to form compound communities. We must, therefore, distinguish different kinds and different degrees of individuality, and may call *hereditary individuality* that kind of independent existence manifested in the successive evolutions of a single egg, producing a single individual, as is observed in all the higher animals. We may call *derivative* or *consecutive individuality* that kind of independence resulting from an individualization of parts of the product of a single egg. We have such derivative individuals among the Nudibranchiate Mollusks, whose eggs produce singly, by a process of complete segmentation, several independent individuals. We observe a similar phenomenon among those Acalephs, the young of which (Scyphostoma) ends in producing, by transverse division (Strobila), a number of independent free Medusæ (Ephyræ). We have it also among the Hydroids which produce free Medusæ. Next, we must distinguish *secondary individuality*, which is inherent in those individuals arising as buds from other individuals, and remaining connected with them. This condition prevails in all the immovable Polyparia and Hydraria, and I say intentionally in the immovable ones; for, in the movable communities,—such as Renilla, Pennatula, etc., among Polyps, and all the Siphonophoræ among Acalephs,—we must still further distinguish another kind of individuality, which I know not how to designate properly, unless the name of *complex individuality* may be applied to it. In complex individuality a new element is introduced, which is not noticeable in the former case. The individuals of the community are not only connected together, but, under given circumstances, they act together as if they were one individual, while at the same time each individual may perform acts of its own.

As to the specific differences observed among Acalephs, there is as great a diversity between them as between their individuals. In some types of this class the species are very uniform,—all the individuals belonging to one and the same species resembling one another very closely, and exhibiting hardly any differences among themselves, excepting such as arise from age. This identity of the individuals of one and the same species is particularly striking among the Ctenophoræ. In this order, there are not even sexual differences among the individuals, as they are all hermaphrodites. In the Discophoræ proper, a somewhat greater diversity prevails. In the first place, we notice male and female individuals; and the difference between the sexes is quite striking in some genera, as, for instance, in Aurelia. Next, there occur frequent deviations among them in the normal number of their parts,—their body consisting frequently of one or two spheromeres more than usual, sometimes even of double the normal number, or of a few less. And yet year after year the same Discophoræ reappear upon our shores, with the same range of differences among their individuals. Among Hydroids, polymorphism prevails to a greater or less extent, besides the differences arising from sex. Few species have only one kind of individuals. Mostly the cycle of individual differences embraces two distinct types of individuals, one recalling the peculiarities of common Hydræ, the other those of Medusæ; but even the Hydra type of one and the same species may exhibit more or less diversity, there being frequently two kinds of Hydræ united in one and the same community, and sometimes even a larger number of heterogeneous Hydræ. And this is equally true, though to a less extent, of the Medusa type. Yet, among Siphonophoræ, there are generally at least two kinds of Medusæ in one and the same community. But, notwithstanding this polymorphism among the individuals of one and the same community genetically connected together, each successive generation reproduces the same kinds of heterogeneous individuals, and nothing but individuals, linked together in the same way. Surely, we have here a much greater diversity of individuals, born one from the other, than is exhibited by the most diversified breeds of our domesticated animals; and yet all these heterogeneous individuals remain true to their species, in one case as in the other, and do not afford the slightest evidence of a transmutation of species.

Would the supporters of the fanciful theories lately propounded, only extend their studies a little beyond the range of domesticated animals,—would they investigate the alternate generations of the Acalephs, the extraordinary modes of development of the Helminths, the reproduction of the Salpæ, etc., etc.,—they would soon learn that there are in the world far more astonishing phenomena, strictly circumscribed between the natural limits of unvarying species, than the slight differences produced by the intervention of men, among domesticated animals; and, perhaps, cease to be so confident, as they seem to be, that these differences are trustworthy indications of the variability of species. For my own part, I must emphatically declare that I do not know a single fact tending to show that species do vary in any way, while it is true that the individuals of one and the same species are more or less polymorphous. The circumstance that naturalists may find it difficult to trace the natural limits of any one particular species, or the mistakes they may make in their attempts to distinguish them, has nothing whatsoever to do with the question of their origin.

There is another feature of the species of Acalephs, which deserves particularly to be noticed. All these animals are periodical in their appearance, and last for a short period in their perfect state of development. In our latitude, most Medusæ make their appearance as Ephyræ early in the spring, and rapidly enlarge to their full size. In September and October, they lay their eggs and disappear; while the young hatched from the eggs move about as Planulæ for a short time, and then become attached as Scyphostomes, and pass the winter in undergoing their Strobila metamorphosis. The Ctenophoræ appear also very early, and lay their eggs in the autumn, passing the winter as young, and growing to their full size towards the beginning of the summer. Among the Hydroids there is more diversity in their periodicity. Hydraria are found all the year round; but the Medusæ buds, the free Medusæ, and the Medusaria make their appearance in different seasons, in different species. Some bring forth Medusæ buds and free Medusæ or Medusaria during winter; others, and in our latitude this is the case with by far the largest number of the Hydroids, produce their Medusæ brood in the spring; while a few breed later, in the summer or in the autumn: so that, notwithstanding the regularity of their periodical return, Acalephs may be studied, in some condition or other, during the whole year.

SECTION VI.

NATURAL LIMITS OF THE CLASS OF ACALEPHS.

The principles upon which the natural limits of this class may be determined have already been discussed (Sect. I. p. 36). They are based upon our knowledge of the structure and embryonic growth of these animals. Upon both points our information is both satisfactory and sufficient. The anatomical researches of the writers quoted from p. 18 to p. 28, and the additional facts I have traced in the preparation of this monograph, cover the ground sufficiently to open a fair view, not only into the general structure of the whole class, but also into the correspondence of the structural features of the different groups of the class, as compared with one another. The same may be said of the embryology of these animals. Besides the data furnished by the investigations already referred to from p. 28 to p. 35, I had most desirable facilities for tracing the embryonic changes of a considerable number of Acalephs. Indeed, I have been able to investigate the embryonic growth of all the types of the class, with the sole exception of the Diphyidæ and Physophoridæ. But Leuckart, Kölliker, Vogt, Gegenbaur, and Huxley have published such full accounts and exhausting researches upon these very families, that little is now wanting to complete the anatomical and embryological history of the whole class. At all events, our comparisons may now extend to every type belonging to this class. And the anatomy and embryology of the other classes of Radiates — the Polyps and Echinoderms — are also sufficiently well known to enable us to institute comparisons between them and the Acalephs, and to trace the differences which bear upon the limitation of their respective classes and subordinate groups. In attempting these comparisons, it is, however, indispensable to bear in mind the difference there is between general and special homologies.

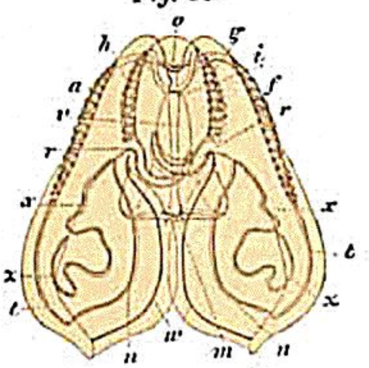
General homologies lead to the knowledge of the identity of such systems of organs as present special structural combinations, and are perhaps adapted to different functions. The extremities of Vertebrates afford a good example of this kind of homologies; the pectoral fins with the thoracic arch of a fish, the wing of a Bird or that of a Bat, and the arms of Man, are identical organs, however different they may appear, between all of which general homologies may be traced. Special homologies, on the contrary, indicate the correspondence of identical parts, differing only in their relative proportions and special adaptations. The different systems of teeth, characteristic of the different genera and families of Mammalia, afford good examples of special homologies; and may be studied from the extensive investigations of Professor Owen upon that subject. Now, the more animals are compared in all their structural details, as well as in their various kinds and different degrees of relationship, the more distinctly does it appear that general homologies are co-extensive with the branches of the animal kingdom, while special homologies are circumscribed within the limits of the classes; or, in other words, that all the classes of one and the same branch have identical systems of organs, however different the organs themselves may be, while the representatives of one and the same class only exhibit identical adaptations in the structure of their organs. Such a distinction, as far as it may be carried out, affords, therefore, a valuable additional test in the delimitation of the classes of animals.

What the types are, which should be referred to the class of Acalephs, will already appear from what has been stated in Section II., p. 41, where I have compared the different types of Radiates with one another. It remains, however, for me to prove that the assertions there made are founded in nature; or, in other words, that the structural features of the animals represented as belonging to the class of Acalephs are not only homologous to one another, in a general way, for this would only prove that they belong to the same branch of the animal kingdom, but that they are homologous in the strictest sense, which will prove them to be members of the same class, if special homologies are really a criterion of class affinities.

The animals which I have considered above as belonging to the class of Acalephs are the Ctenophoræ, the Discophoræ, the Hydroids proper, and the Siphonophoræ, within the limits ascribed to these groups by most authors. I have no hesitation in referring all these to the Acalephs; nor do I think there can be any doubt left that Hydra and the Tabulata, still referred to the class of Polyps by Milne-Edwards, also belong to that of Acalephs. To these I would further add the Rugosa, a type of Corals first recognized as distinct by Milne-Edwards, and referred by him to the class of Polyps. Respecting these last, some uncertainty still remains, since they are all fossil, and their affinities can only be inferred from the structure of their solid parts. As to all the other groups, the evidence that they belong to the class of Acalephs seems to me satisfactory, though it is not throughout of the same kind. For instance, the evidence that the Ctenophoræ are Acalephs is altogether anatomical, and chiefly based upon the special homologies of their parts: it receives no additional confirmation from Embryology, as the young at birth are already very similar to the parent, and do not exhibit those complex relations which we observe in other Acalephs. The affinities of the Discophoræ, Siphonophoræ, and Hydroids, on the contrary, are established upon embryological as well as anatomical evidence.

Beginning with the Ctenophoræ, we have first to sift the arguments brought forward to support their connection with the Mollusks. The idea that the Ctenophoræ are allied to the Tunicata, and especially to the Salpæ, was first suggested by Quoy in the Zoölogy of the Astrolabe (vol. 4, p. 36), and afterwards more fully developed by Vogt in his Zoölogical Letters (vol. 1, p. 254), where he represents them as a distinct class, intermediate between the Bryozoa and the Tunicata, which are themselves also considered as distinct classes. The ground upon which they are brought to the branch of Mollusks is chiefly their bilateral appearance; and it is there stated, that, with the exception of their glassy transparency, they have not one trait of their organization in common with the Acalephs. Such an assertion, from a naturalist to whom science owes important contributions to our present knowledge of an extensive and most intricate group of Acalephs (the Siphonophoræ), cannot be passed unnoticed. That Bryozoa and Tunicata are bilateral animals and truly belong to the type of Mollusks, is unquestionable; and that the Ctenophoræ share the peculiar consistency of their body as fully with the Salpæ as with the common Acalephs, might appear true were it not known that the Ascidians, to which Salpæ belong, have a mantle consisting of Cellulose,[1] while of all Acalephs the Ctenophoræ are the most perishable, and dissolve entirely in water,—their body, however, consisting of cells of the same kind as those of the other Acalephs.

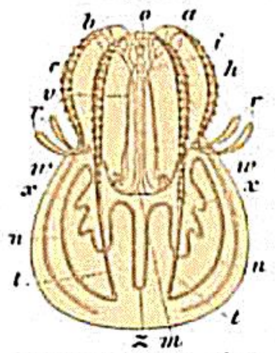
Fig. 54.



BOLINA ALATA, Ag.
(Seen from the broad side.)

a and *f* Long rows of locomotive fringes.—*g* and *h* Short rows of locomotive fringes.—*o* Central black speck (eye-speck?).—*i* to *m* Triangular digestive cavity.—*i* to *o* Funnel-like prolongation of the main cavity.—*v* Chymiferous tube of the tentacular apparatus.—*m* Tentacular apparatus on the side of the mouth.—*r r* Ear-like lobe, or auricles, in the prolongation of the short rows of locomotive fringes.—*t t* Prolongation of the vertical chymiferous tubes.—*n n* The same tubes turning upwards.—*x x* Bend of the same tubes.—*z z* Extremity of the same tubes meeting with those of the opposite side.—*w* Recurrent tube anastomozing with those of the auricles.

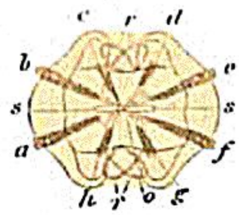
Fig. 55.



BOLINA ALATA, Ag.
(Seen from the narrow side.)

a b Long rows of locomotive fringes.—*c h* Short rows of locomotive fringes.—*o* Central black speck (eye speck?).—*i* Upper end of the digestive cavity.—*i* to *o* Funnel-like prolongation of the main cavity of the body.—*m* to *i* Digestive cavity.—*r r* Auricles.—*m* Mouth.—*t t* Prolongation of the vertical chymiferous tubes.—*n n* The same turning upwards.—*x x* Bend of the same tubes.—*z* Anastomosis of the two longitudinal tubes *t t*.—*w w* Recurrent tube, anastomozing with those of the auricles.—A comparison of this figure with *Fig.* 4 gives a distinct idea of the relative position of the digestive cavity *m* to *i*, and the chymiferous tubes of the tentacular apparatus *v*.

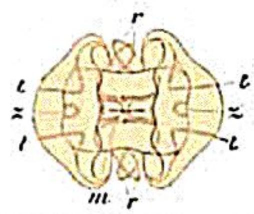
Fig. 56.



BOLINA ALATA, Ag.
(Seen from above.)

o Central black speck (eye speck?).—*a b e f* Long rows of locomotive fringes.—*c d g h* Short rows of locomotive fringes.—*r r* Auricles.—*s s* Circumscribed area of the upper end of the body.

Fig. 57.



BOLINA ALATA, Ag.
(Seen from below.)

m Mouth.—*r r* Auricles.—*t t t t* Prolongation of the vertical chymiferous tubes.—*z z* Anastomosis of these tubes.

As to the assertion that the Ctenophoræ are bilateral animals, it is only in so far correct that the body is more or less compressed, as the adjoining wood-cuts show (*Figs.* 54, 55, 56, and 57), which represent a Bolina most common along the northern Atlantic coast of America. But the arrangement of all the parts of these animals is truly radiate. Their bilateral appearance is only the result of the inequality of their spheromeres, as is the case with the Spatangoids also, and, in a less degree, with all Echinoderms. But in all these animals the structure is typically radiate, and the bilaterality subordinate to the plan of radiation, in the same manner as in Cephalopods and in Bryozoa the radiated arrangement of the arms and tentacles is subordinate to their bilateral type. The closest comparison of the structure of the Ctenophoræ with that of the Bryozoa and Tunicata on one side and the common Medusæ on the other, will show, that, while all their

[1] See the memorable paper of KÖLLIKER and LÖWIG: De la composition et de la structure des enveloppes des Tuniciers. Ann. Sc. Nat. 3e sér. vol. 5, p. 193.

parts are strictly homologous to those of the Acalephs, they bear no resemblance to those of Mollusks. I have purposely selected, for this comparison, one of the Ctenophoræ in which the bilateral symmetry is most prominent, that the bilateral appearance may not seem intentionally lessened. In our Bolina alata seen from above (*Fig.* 49), there appear eight rays, diverging from the centre: these are formed by the eight rows of locomotive flappers which extend, like meridians, upon the sides of the body. Under these flappers extend eight chymiferous tubes, which are symmetrically radiate in their arrangement, like the ambulacral rows upon the sides of a Sea-urchin. But this is not all. These tubes are also homologous to the radiating chymiferous tubes of the ordinary Medusæ, and to the ambulacral system of the Echinoderms; and while they bear only a general homology to the latter, they have the most special homology to the radiating tubes of the Medusæ. In both they arise from the main cavity of the body; in both they diverge from that centre towards the periphery; in both they connect through anastomoses at the periphery; in both they carry the nutritive fluids to all parts of the body; in both they are accompanied by the sexual organs; while neither Bryozoa nor Tunicata, nor any other Mollusks, have such radiating tubes. In the Ctenophoræ, as in the other Acalephs, the digestive cavity is hollowed out of the mass of the body, with the single difference that the abactinal end of that cavity is freed from the spherosome in Ctenophoræ, while it is not so in the other Acalephs. The Bryozoa and Tunicata, on the contrary, have a distinct alimentary canal entirely free from the walls of the body, and provided with two openings; besides which Tunicata have a heart and a gill, and muscular bundles arranged symmetrically upon the two sides of the body. Fuller evidence of the bilateral structure of the Bryozoa and Tunicata, and of their typical difference from the Ctenophoræ, could hardly be desired.

Assuming, then, that the Ctenophoræ are genuine Radiates, it remains to be seen whether they form a class by themselves, as not only Vogt, but also Leuckart and Gegenbaur, will have it, or whether they are only members of the class of Acalephs: for I hold that naturalists have no more right to please themselves in the limitation of the classes, than in the limitation of genera and species, or any part of a systematic exposition of the relations of animals; and that their task should simply consist in ascertaining, upon clearly defined principles, what nature teaches us respecting these affinities. They may, no doubt, disagree in the application of these principles; but a purely arbitrary classification is no longer admissible. The validity of every group proposed hereafter by an investigator must be discussed before it is admitted or rejected; and the principles upon which the discussions are conducted will themselves become more precise, and be settled more firmly by these discussions.

If, then, classes are characterized by the mode of execution of a given plan, the Ctenophoræ being radiated animals, we have only one point more to ascertain respecting them. Does their structure exhibit only a general homology to that of the Acalephs, or are the Ctenophoræ linked to the ordinary Acalephs by special homologies? What has already been said when considering their typical relations seems to me conclusive in that respect. Ctenophoræ differ only in degree, and not in kind, from the animals thus far generally considered as true Medusæ; they must, therefore, be considered as belonging to the class of Acalephs, in which, as we shall see in the next section, they constitute a natural order.

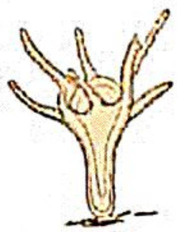
As the Discophoræ have always been considered as the typical group of the class of Acalephs, and as the Acalephian character of all the other groups that have successively been associated with them, or removed from them, has uniformly been measured by the degree of their affinity to the Discophoræ, as soon as it is ascertained that these animals exhibit a special mode of execution of the plan of radiation, the independence of the Acalephs, as a class, is also proved. And this has already been done in a preceding section (p. 65). In the next, we shall consider the position of the Discophoræ in their class, amidst all the other representatives of that class.

The evidence that the Hydroids should be associated in one and the same class with the Discophoræ and Ctenophoræ is of two kinds. In the first place, Hydroids produce Medusæ; next, they are not themselves Polyps, as was long admitted. The first of these facts furnishes a direct argument for the necessity of uniting that kind of Hydroids with the other Acalephs; and the circumstance that the Hydroids from which free Medusæ arise are not identical in their structure with Polyps, but themselves resemble Medusæ more than Polyps, in connection with what is already known of the reproduction of the latter, shows that Polyps never produce free Medusæ, but that the Polyp-like animals, from which free Medusæ arise, are themselves Acalephs.

It is hardly necessary, nowadays, to demonstrate that such animals as Sarsia, Lizzia, Zanclea, Cladonema, Hippocrene, Nemopsis, Hybocodon, Tiaropsis, Thaumantias, etc., are genuine Medusæ. Their close affinity to the highest representatives of this order of Acalephs has been recognized by all the investigators of this class of animals. Péron and LeSueur, Eschscholtz, deBlainville, Milne-Edwards, Lesson, Sars, Forbes, Dujardin, Leuckart, Gegenbaur, and others have expressed their conviction that they are such, not only by direct declarations, but also in various other ways, when alluding to them. To the arguments adduced by other investigators, new facts have been more recently added: their mode of reproduction has been made known; their sexual organs have been studied; the development of their eggs has been traced through every stage of growth; the formation of their spermatic particles in the sperm cells has been observed; their special homologies with the highest Discophoræ have been made out; and nothing is wanting to prove that the naked-eyed Medusæ, in their adult condition, are genuine Acalephs, closely allied to the covered-eyed Discophoræ. The naturalists who, having identified them with the so-called sexual bunches of the Siphonophoræ, would consider them as free sexual organs because these bunches appear to them to be sexual organs, and not clusters of sterile Medusæ, are bound to show that spermaries and ovaries may have the structure of perfect Medusæ, that is, a gelatinous bell, radiating and circular chymiferous tubes, and a proboscis; not simply by affirming that certain low sessile Medusæ are sexual organs, but by adducing the evidence of a similar structure of the sexual organs in other Acalephs. The burden of furnishing that proof rests with them, because other naturalists have already shown that these supposed free sexual organs, including the gonocalyx of the Diphyidæ and the androphores and gynophores of the Physophoridæ, not only exhibit all the characteristic structural features of genuine Acalephs, but are themselves either male or female individuals provided with ovaries and spermaries.

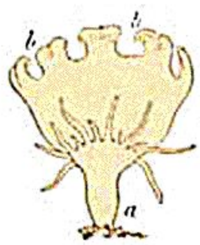
As the divergence of opinions upon this point has arisen from the peculiar phenomena known as alternate generations, it is proper that we should now turn our attention to this subject for a moment, and examine critically the distinctive features of the various facts now generally considered as constituting one peculiar mode of reproduction; since, from the beginning, heterogeneous phenomena have been confounded under that name. Without stepping beyond the limits of the class of Acalephs, we have, in the first place, the case of the higher Discophoræ, in which, as for instance in Aurelia and Cyanea, the young born from eggs (Pl. X. *Figs.* 1 and 2, and Pl. X^a. *Figs.* 16–24) as independent, locomotive, single individuals (Pl. X. *Figs.* 3 to 10, and Pl. X^a. *Figs.* 25 to 36), become attached (Pl. X. *Figs.* 11, 12, 13, and 14), and then tentacles appear gradually (Pl. X. *Figs.* 13 and 14), the young thus assuming the form of Hydræ, with an increasing number of tentacles (Pl. X. *Figs.* 16 to 37, and Pl. X^a. *Figs.* 11 to 15). The body is next furrowed by transverse grooves, and assumes an annulate appearance, and the rings thus formed (Pl. XI. *Fig.* 19) become gradually more distinct and more numerous, until the Hydra is changed into a Strobila, which is only a Hydra undergoing a process of transverse segmentation. As the process of isolation resulting from a deeper and deeper contraction of the ambulacral segments becomes more complete, the whole resembles a pile of scalloped saucers, with a fringe of tentacles; next, the uppermost segment drops off; then the next disk, then the next, and so on until in the end, each disk has separated successively from that below (Pl. XI. *Fig.* 29), and the base of the original Hydra, having reproduced tentacles, remains alone, perhaps with a few disks attached to it (Pl. XI. *Figs.* 1, 4, and 17), or with a single disk, as in *Fig.* 13. These free disks are genuine Medusæ, and have long been known as Ephyræ (Pl. XI[a]).—*Figs.* 58, 59, and 60, below, represent a summary history of this mode of reproduction.—The Ephyræ are, in course of time, transformed into common Medusæ: those of our Aurelia flavidula, *Pér. and LeS.*, *Fig.* 60, assume the characters of that genus, consisting in innumerable small tentacles all along the margin of the disk, with four long, pendent so-called arms around the mouth, etc. (comp. Plates VI., VII., and VIII.); while those of Cyanea arctica, which at first hardly differ from those of Aurelia, are transformed into the largest Jellyfish of our coast, and end in having the appearance of Pl. III., III.[a], IV., and V.

Fig. 58.



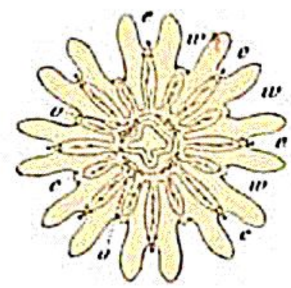
Scyphostoma of AURELIA FLAVIDULA, Pér. & LeS.
In this stage of growth, Aurelia is simply a Hydroid.

Fig. 59.



Strobila of AURELIA FLAVIDULA, Pér. & LeS.
a Scyphostoma reproduced at the base of a Strobila *b b*, all the disks of which have dropped off but the last.

Fig. 60.



Ephyra of AURELIA FLAVIDULA, Pér. & LeS.
c Mouth.—*e e* Eyes.—*o o* Ovaries.—*w w* Tentacular spaces.

We have thus a *complete metamorphosis of an Ephyroid animal into a perfect Medusa* entirely different from it both in form and complication of structure, and this metamorphosis is the sequel of another series of genetic phenomena, during which *one single being* arising from an egg of Aurelia or Cyanea, at first free and afterwards attached, *ends in dividing into a dozen and more, may be twenty and more, distinct free Ephyræ,* without ceasing to live, for the Strobila reproduces tentacles below the last Ephyra (*Fig.* 59) before this drops off, and resumes its Scyphostoma or Hydra form. Now, this part of the process is neither a metamorphosis proper nor an alternate generation comparable to that of the ordinary Hydroids, for here the body of the Hydra is partially lost in the formation of the Ephyræ. The crown, or row of tentacles, at its actinal end, after separating, dies and decomposes; while the central portion of the Hydra, intermediate between the tentacles and its abactinal end, divides into numerous free, active Ephyræ, which continue to live until they have completed their metamorphosis, and laid an immense number of eggs. The base of the Hydra, with its new tentacles, also survives, and may live for years. Its further history, to which I shall allude again hereafter, still presents, however, some mystery.

In the Hydroids proper, which also produce free Medusæ, the origin of the free brood is entirely different, and truly leads to a succession of alternate generations. Arising from the eggs of their free Medusæ, these Hydroids, when mature, bring forth buds from different parts of their axis, in different families, and even in different genera of the same family. These buds start either from the stem or from the upper part of the body, or even from the proboscis of the Hydra: they gradually enlarge, and assume the appearance of Medusæ, even while still connected with the Hydra, and free themselves finally, and become independent animals, undergoing but slight changes comparatively after their separation, except that they grow larger, develop their sexual organs, and finally lay eggs, out of which arise new Hydræ. The Hydræ themselves undergo no changes whatever in consequence of this production of free Medusæ: they neither lose their tentacles nor any part of their body, and continue to live for an indefinite period of time, and may produce other crops of free Medusæ,—although I have not traced directly such a repetition of their reproduction.

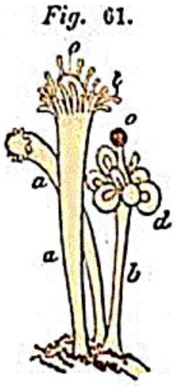
Here, as in the case of Aurelia and Cyanea, the connection of the free Medusæ and the Hydræ is unquestionable, and hardly less direct in the one than in the other; for, though the Ephyræ are parts of the body of Hydræ, the free Medusæ of the common Hydroids are buds from Hydræ, some of which differ but slightly from the Hydræ of Aurelia and Cyanea. If, therefore, the Hydræ from which Ephyræ arise, belong to the class of Acalephs as young of the highest type of Discophoræ, surely the Hydræ born from the eggs of naked-eyed Medusæ, though reproducing again the same kind of Medusæ only through buds, must equally belong to that class; and this the more since these Hydræ themselves have already been shown to be strictly homologous to Acalephs, and not to Polyps (p. 44). The doubts entertained by some naturalists respecting the systematic position of the Hydroids have arisen from a belief that Hydroids were Polyps, in connection with the fact, disclosed during the last twenty years, that they produce free Medusæ, when the following alternative seemed inevitable: either must Polyps and Acalephs be united as a class, or, if considered distinct, it must be acknowledged that Polyps produce Medusæ. But neither is true. Hydroids are not genuine Polyps, and the true Polyps may be considered as a distinct class, without forcing upon us the conclusion that they produce Medusæ; since the Polyp-like Radiates from which free Medusæ arise are themselves a low type of Acalephs, remarkable for the polymorphism of its representatives. And yet, however great the diversity of the individuals of one and the same kind of these Acalephs may be, it is easily reduced to two forms, one of which belongs to the Hydra type, the other to the Medusa type.

The genetic connection of certain Hydroids and certain free Medusæ once established, it remains only to be settled what are the kinds of Acalephs which should be considered as belonging to their type, among those Hydroids not known to produce free Medusæ and among those Medusæ not known to originate from

Hydroids; and also under what common name they should be designated. The answer to these two questions is not difficult.

Since the free Medusæ known to originate from Hydroids all belong to the type of the *Discophoræ Cryptocarpæ* of Eschscholtz, the *Gymnophthalmata* of Forbes, or *Craspedota* of Gegenbaur, there is presumptive evidence that the final investigation of the true affinities of these Medusæ will lead to a natural association of all those which are really and closely related to one another, to the exclusion of the possible foreign admixtures now left in this group, and that such a natural group will in the end embrace all the Medusæ originating from Hydroids. It is also possible, however, that such a natural group of Medusæ may embrace genera undergoing a direct metamorphosis from the egg to the perfect Medusa without intervening Hydra stock, as we already know that there are higher Discophoræ, such as Pelagia, which reproduce themselves without passing through the Strobila state. But this would not alter the case of the affinity of such Medusæ: it would only show that the natural group to which they belong exhibits a wider range in its modes of development. The systematic position of any Medusa must be determined by an investigation of its special structure, and if there are any Medusæ, not arising from Hydroids, but growing up directly from eggs to their permanent form, and presenting the same special structure as those that arise from Hydroids, there is no reason why they should be separated. Upon this view we shall hereafter consider the affinities of the Æquoridæ, the mode of development of which is not yet fully ascertained, and those of the Æginidæ, some of which are known to undergo a direct metamorphosis. As to the Polyp-like Acalephs already known to produce free Medusæ, they have all been united by Johnston into one natural division, which he has called *Hydroidea.* But among these Hydroidea there are those which produce no free Medusæ, and yet as Hydroids in no way differ from those that produce them. There is, therefore, no reason why they should be separated: the less since, instead of free Medusæ, they produce sessile Medusæ buds identical in their structure with the free Medusæ originating from the other Hydroids. On account of its resemblance to Siphonophoræ, Hydractinia (*Figs.* 61 and 62) affords an excellent example of this type.

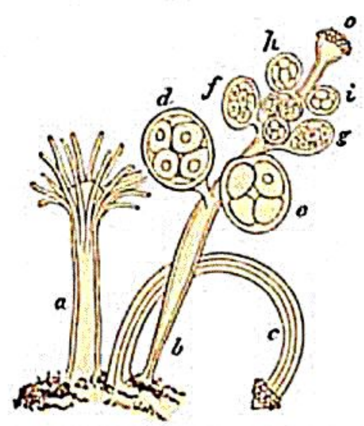
Fig. 61.



HYDRACTINIA POLYCLINA, Ag.

a a Sterile individuals. — *b* Fertile individual, producing male Medusæ. — *d* Clusters of male Medusæ. — *o o* Proboscis, with the mouth at the apex. — *t* Elongated tentacles of the sterile individuals; in the fertile one *b*, they are simple knobs *o*.

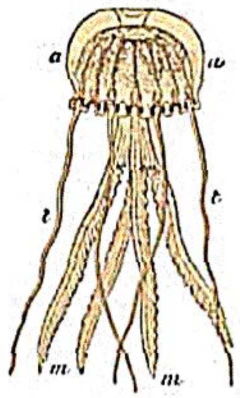
Fig. 62.



HYDRACTINIA POLYCLINA, Ag.

a Sterile individual. — *b* Fertile individual producing female Medusæ. — *d e* Female Medusæ, containing advanced eggs. — *f g h i* Cluster of female Medusæ with less advanced eggs. — *o* Peduncle of the mouth with short globular tentacles. — *c* Individual, with globular tentacles, upon which no Medusæ have as yet appeared, or from which they have already dropped.

Fig. 63.



PELAGIA CYANELLA, Pér. and LeS.

a a Umbrella. — *m m* Mouth tentacles or arms; the prolongation of the angles of the mouth. — *t t* Marginal tentacles.

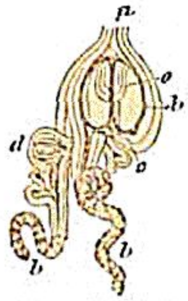
It appears thus, that, whether originating from Hydroids or not, all genuine Gymnophthalmata, the Discophoræ Cryptocarpæ of Eschscholtz, must be united into one great natural division with all the genuine Hydroids, whether these produce free Medusæ or not. But, while I acknowledge that the free Medusæ born from Hydroids show their Acalephian

Fig. 64.

HYBOCODON PROLIFER, Ag.

a Stem of a single Hydra. — *o* Its mouth surrounded with tentacles. — *t t* Its marginal tentacles. — *d d d* The most advanced of its Medusæ buds.

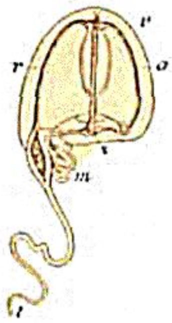
Fig. 65.



Medusa bud of
HYBOCODON PROLIFER, Ag.

a Base of attachment to the Hydra stock. — *o* Proboscis. — *c* Circular chymiferous tube. — *b* Radiating chymiferous tube. — *d t* Proliferous Medusa with its single tentacle. — *t* Single tentacle of the primary Medusa. — Near *c* Another small proliferous Medusa-bud.

Fig. 66.



Free Medusa of
HYBOCODON PROLIFER, Ag.

The longest vertical tube being seen in profile.

v Proboscis. — *r o* Radiating tubes. — *s* Circular tube. — *t* Tentacle. — *m* Buds of Medusæ, proliferous from its base.

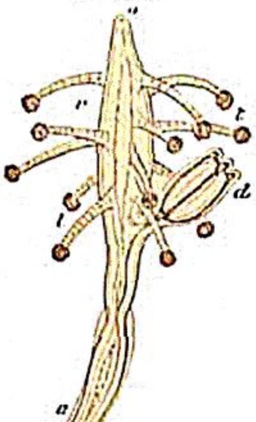
Fig. 67.

Free Medusa of
HYBOCODON PROLIFER, Ag.

Facing the longest chymiferous tube.

a Point of attachment before its separation. — *b c* Radiating or vertical chymiferous tubes, *c* pointing to the circular tube. — *t* Tentacle. — *f* Bunch of proliferous Medusæ buds. — *e* Rows of epithelial cells forming distinct bands at the surface. — *o* Proboscis.

Fig. 68.

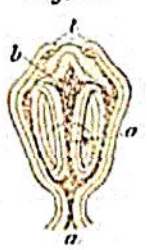


CORYNE MIRABILIS, Ag.

Hydra with a Medusa bud. This bud when freed becomes a Sarsia, *Fig.* 70.

a Stem of the Hydra. — *v* Its club-shaped body. — *o* Its mouth. — *t t* Tentacles scattered over the body. — *d* Medusa bud.

Fig. 69.

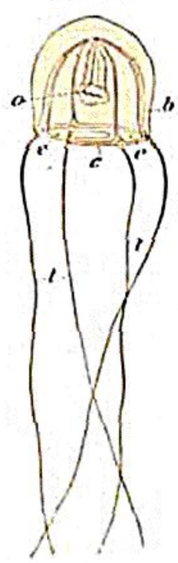


Medusa bud of
CORYNE MIRABILIS, Ag.

The bud represented here separately, with its base of attachment *a* cut through, is younger than that represented in its natural connection in *Fig.* 68 *d*. The free Medusa is represented *Fig.* 70, and described as *Sarsia mirabilis* in the Contributions to the Nat. Hist. of the Acalephs.

a Base of attachment to the Hydra stock. — *o* Proboscis. — *b* Radiating chymiferous tubes. — *t* Tentacles. — All the intermediate forms, from the youngest buds to the adult Medusæ, will be described in the next volume.

Fig. 70.



The free Medusa, SARSIA, of
CORYNE MIRABILIS, Ag.

o Proboscis. — *b* Vertical chymiferous tube. — *c* Circular tube. — *e e* Diaphragm. — *t t* Tentacles.

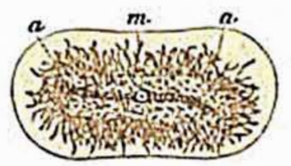
nature in the resemblance they bear to the common Medusæ of the type of Aurelia, Cyanea, and Pelagia (*Fig.* 63), I do not believe that their affinity to the latter is sufficiently close to justify their association with them in one and the same order. (Compare *Figs.* 65, 66, and 67, which are the Medusæ buds and the free Medusa of the Hydroid of *Fig.* 64; and *Figs.* 69 and 70, which are the Medusæ buds and free Medusa of the Hydroid of *Fig.* 68, with genuine Discophoræ as represented in *Fig.* 63.) I take here, therefore, the group of Discophoræ Cryptocarpæ (*Figs.* 66, 67, and 70) as entirely distinct from that of Discophoræ Phanerocarpæ (*Fig.* 63), for which alone, I shall retain the name of Discophoræ. For the present, I desired only to trace the natural limits of the class of Acalephs, to give examples of their various types, and to prove that the Hydroids cannot be separated from the naked-eyed Medusæ any more than from the Siphonophoræ. We shall see presently that this natural division differs essentially, as an order, from the *Discophoræ* proper, the *Steganophthalmata* of Forbes, or *Acraspeda* of Gegenbaur.

Fig. 71.

Free Medusa of VELELLA MUTICA, Bosc.

o Proboscis. — *b* Radiating chymiferous tubes. — *c* Circular tube.

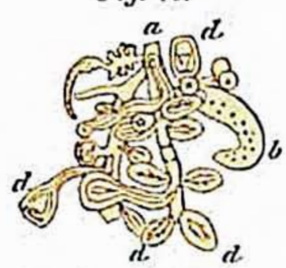
Fig. 72.



VELELLA MUTICA, Bosc.

m So-called mouth. — *a a* So-called tentacles. Between the sterile tentacles and the mouth arise the secondary Hydræ, or so-called fertile tentacles, the gonoblastidial Polypites of Huxley.

Fig. 73.



Bunch of Medusæ of PHYSALIA ARETHUSA, Til.

In various stages of development.

a Common hollow base of attachment of the whole bunch, communicating with the chymiferous cavity of the air sac. — *b* So-called Polyp, or sucker. — *d d d d* The Medusæ buds arising from the simplest kind of Hydræ existing in the whole community.

Fig. 74.

Bunch of single Hydræ and clusters of Medusæ of PHYSALIA ARETHUSA, Til.

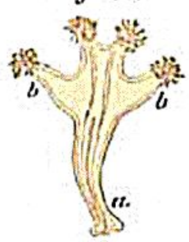
b b The Hydræ, with their tentacles *c c*. — *d d* The bunches of Medusæ.

For the united Gymnophthalmata and Hydroidea, there is only one name acceptable, according to the law of priority: they must be called HYDROIDÆ. But this order must further include the Siphonophoræ, since they likewise exhibit two structural types, some individuals of their communities being Hydræ and others Medusæ, variously combined, and the Medusæ either becoming free (*Fig.* 71, derived from *Fig.* 72) or remaining sessile (*Figs.* 73 and 74), as among the majority of the Hydroids proper.

As soon as the different families of this order are brought together side by side, and their structure and modes of development are compared, it is impossible to overlook the typical conformity which exists among them, and unites them all into one natural group. Had the peculiar modes of reproduction of the Acalephs been known as early as their adult condition, this affinity would have been much sooner recognized. The idea of pedunculated Acalephs, attached to the ground, must have appeared unnatural to those who were familiar with the large free Medusæ so common everywhere; and it is hardly a matter of surprise that even now, there should be naturalists who oppose the views I have here presented. Let it be remembered, however, that it is not so very long since the pedunculated Crinoids were arranged among the Polyps, and that it has only required a direct comparison between them and the free Crinoids to show their close affinity with the other members of the class of Echinoderms. Now, the pedunculated Hydroids bear the same relation to the swimming Hydroids (the Siphonophoræ) as the pedunculated Crinoids bear to the free Crinoids; and, the close affinity of the Siphonophoræ and Hydroids proper once admitted, their mode of reproduction renders their separation from the higher Acalephs forever impossible, while it forbids, at the same time, their association with the Polyps.

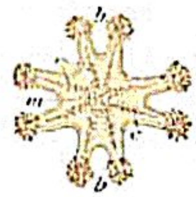
That Lucernaria (*Figs.* 75 and 76) and Millepora (*Figs.* 77, 78, and 79) belong to the Hydroids proper has already been shown (pp. 59 and 61). The nearest affinity of Millepora is with Hydractinia (compare *Figs.* 61 and 62); but its mode of reproduction has thus far remained unknown.

Fig. 75.



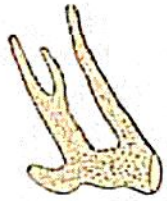
LUCERNARIA,
Seen in profile.
a Peduncle. — *b b* Tentacular bunches.

Fig. 76.



LUCERNARIA,
Seen from above.
m Mouth. — *c c* Ovaries.
b b Tentacular bunches.

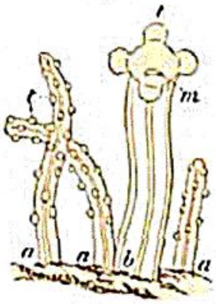
Fig. 77.



MILLEPORA ALCICORNIS, Lmk.

A branch of the Coral of that name, natural size. The little projections along the edge are meant for the extended Polyps. They are extremely shy and delicate, and never show themselves again after a branch has once been taken out of the water.

Fig. 78.



MILLEPORA ALCICORNIS, Lmk.

Magnified view of the extended Polyps or Hydroids of the same Coral stock.

a a Smaller Hydroids. — *b* Larger Hydroid, *m* its mouth, *t* its tentacles.

Fig. 79.

MILLEPORA ALCICORNIS, Lmk.

Transverse section of a branch of the Coral stock, magnified.

a a Pits of the Hydroids, with their successive floors. It is very difficult to obtain sections of the pits occupied by the smaller Hydroids.

The structural features of all these various representatives of the class of Acalephs will, of course, be more fully illustrated in the following chapters. My object here was mainly to show, upon the most general evidence, what are the types of Radiates that constitute the class of Acalephs, and incidentally to call attention to their special affinities. If the views I entertain upon this subject are correct, this class embraces three orders, — the CTENOPHORÆ, the DISCOPHORÆ proper, to the exclusion of the naked-eyed Medusæ, and the HYDROIDÆ, including the naked-eyed Medusæ, the Hydroids proper, the Siphonophoræ, the Milleporidæ with all the Tabulata of Milne-Edwards, and perhaps the Rugosa also, if their true affinity is actually indicated by the peculiarities of their solid parts and their resemblance to those of the Tabulata.

When considering Individuality and Specific Differences as manifested in the class of Acalephs, I have taken an opportunity of showing, upon general grounds, how futile the arguments are upon which the theory of transmutation of species is founded. Having now shown that that class is circumscribed within definite limits, I may be permitted to add here a few more objections to that theory, based chiefly upon special grounds, connected with the characteristics of classes. If there is any thing striking in the features which distinguish classes, it is the definiteness of their structural peculiarities; and this definiteness goes on increasing, with new and additional qualifications, as we pass from the class characters to those which mark the orders, the families, the genera, and the species. Granting, for the sake of argument, that organized beings, living at a later period, may have originated by a gradual change of those of earlier periods, one of the most characteristic features of all organized beings remains totally unexplained by the various theories brought forward to explain that change, — the definiteness of their respective groups, be these ever so comprehensive or ever so limited, combined with the greatest inequality in their numeric relations. There exist a few thousand Mammalia and Reptiles, and at least three times their number of Birds and Fishes. There may be about twenty thousand Mollusks; but there are over one hundred thousand Insects, and only a few thousand Radiates. And yet the limits of the class of Insects are as well defined as those of any other class, with the sole exception of the class of Birds, which is unquestionably the most definite in its natural boundaries. Now, the supporters of the transmutation theory may shape their views in whatever way they please, to suit the requirements of the theory, instead of building the theory upon the facts of nature, and they can never make it appear that the definiteness of the characters of the class of Birds is the result of a common descent of all Birds; for the first Bird must have been brother or cousin to some other animal that was not a Bird, since there are other animals besides Birds in the world, to no one of which does any Bird bear so close a relation as it bears to its own class. The same argument applies to every other class. And as to the facts, they are fatal to such an assumption; for Geology teaches us that among the oldest inhabitants of our globe known, there are representatives of nine distinct classes of animals, which by no possibility can be descendants of one another, since they are contemporaries.

The same line of argument and the same class of facts forbid the assumption that either the representatives of one and the same order, or those of one and the same family, or those of one and the same genus, should be considered as lineal descendants of a common stock; for orders, families, and genera are based upon different categories of characters, and not upon more or less extensive characters of the same kind, as I have shown years ago (vol. 1, p. 150–163), and numbers of different kinds of representatives of these various groups make their appearance simultaneously in all the successive geological periods. There appear together Corals and Echinoderms of different families and of different genera in the earliest geological formation, and this is equally true of Bryozoa, Brachiopods, and Lamellibranchiates, of Trilobites and the other Crustacea, in fact of the representatives of all the classes of the animal kingdom, making due allowance for the period of the first appearance of each; and at all times and in all classes, the representatives of these different kinds of groups are found to present the same definiteness in their characteristics and limitation. Were the transmutation theory true, the geological record should exhibit an uninterrupted succession of types, blending gradually into one another. The fact is, that throughout all geological times, each period is characterized by definite, specific types, belonging to definite genera, and these to definite families, referable to definite orders, constituting definite classes, and definite branches built upon definite plans. Until the facts of nature are shown to have been mistaken by those who have made them known, and that they have a different meaning from that now generally assigned to them, I shall, therefore, consider the transmutation theory as a scientific mistake, untrue in its facts, unscientific in its method, and mischievous in its tendency.

SECTION VII.

GRADATION AMONG ACALEPHS.

Confident that I have correctly ascertained the limits of the class of Acalephs, and that the method I have followed in that investigation is the only one that may furnish the means of avoiding arbitrary decisions with reference to the natural affinities of animals, I now proceed to an inquiry into the gradation or relative standing of the different members of this class. Keeping in view the principles laid down in the first volume of this work (p. 150), this inquiry should lead us to a knowledge of the *Orders* among Acalephs, if orders, as natural divisions, are based upon the different degrees of complication of the structure of the members of one and the same class; and that this is the true view to take of orders, I have at present not the least doubt. It is certainly so in all the classes, of which the natural orders have been most fully investigated. It is so among Polyps, if the Actinoids and Halcyonoids constitute natural orders in that class; for the Halcyonoids, with their eight spheromeres, and lobed tentacles, stand higher than the Actinoids. It is so among Echinoderms, the orders of which truly correspond to different degrees of complication of their structure, and most naturally mark the relative rank of these animals. It is so among Crustacea, taking the Rotifera, the Entomostraca, the Isopods, the Amphipods, the Stomatopods, and the Decapods as their natural orders. It is so among Acephala, if the Bryozoa, the Brachiopods,[1] the Tunicata, and Lamellibranchiata constitute natural orders. This gradation, in accordance with the complication of structure, is equally apparent among the Batrachians and the true Reptiles; and if it is not traceable at present with the same certainty in all the classes of the animal kingdom, I am inclined to believe that it is not because this principle is incorrect, but because we have not yet obtained a satisfactory standard, by which to determine the relative importance of their structural differences. At all events, a majority of the classes, and those best known to me, coincide with the view I have expressed respecting the meaning of orders. It would be surprising should there be some classes in which no such gradation exists, when it is so apparent in others. Let us now see what are the different degrees of complication of structure observed among Acalephs.

After tracing the special homologies of the Ctenophoræ, and ascertaining their close relationship to the ordinary Medusæ, it is evident that they belong to the class of Acalephs; but in this class they constitute a natural and distinct order. Their chief difference from the Discophoræ consists in the mode of ramification of the chymiferous tubes, originating in two main trunks, in opposite directions, each of which is divided into two horizontal branches, and each branch into two horizontal forks; so that the number of horizontal chymiferous tubes is always eight. But, unlike other Acalephs, these tubes do not terminate at the periphery, but open into eight vertical branches, converging in opposite directions towards the actinal and the abactinal ends of the body, and giving out minor branches into the spherosome. The main trunks of these vertical branches are parallel to the surface of the spherosome, and follow the same course as the rows of locomotive flappers, which extend, like eight ribs, upon the surface of the body. Towards the actinal and towards the abactinal poles of the spherosome, the vertical branches of

[1] The position I have assigned to the Brachiopods, near the Bryozoa, has been confirmed by a paper just published, in which a Brachiopod is described, resembling so closely a young Bryozoan just hatched from the egg, that the conclusion is irresistible that Bryozoa and Brachiopods are more closely related to one another than any other groups of Acephala. See Beschreibung einer Brachiopodenlarve von Fritz Müller in Desterro (Brasilien). in Archiv für Anat. Phys. und wiss. Med. 1860, p. 72.

the chymiferous tubes terminate in different ways in different genera; anastomozing in a more or less direct manner with one another around the actinostome. Besides the vertical chymiferous tubes which follow the course of the rows of flappers, there are two other vertical chymiferous tubes, presenting various degrees of complication in different genera. These two tubes are placed opposite to one another, in the same direction as the main branches of the whole system. All Ctenophoræ have a decided tendency to a bilateral symmetry, their body being more or less compressed. In some the outline is spheroidal, in others more cylindrical, while in others still, the spherosome expands on the actinal side of the body into wing-like appendages.

The most prominent peculiarities of the Ctenophoræ as an order consist, therefore, in the complication of their system of chymiferous tubes, in the presence of locomotive flappers on the surface, and in a tendency to a bilateral symmetry, resulting from the inequality of their spheromeres.

All these peculiarities show distinctly that the Ctenophoræ are superior to the Discophoræ; for in the latter the chymiferous tubes simply radiate from the main cavity towards the periphery, and, when branching, divide in one and the same plane. Moreover, Discophoræ have no rows of locomotive flappers, and move only by the contraction of their spherosome, which assumes the form of a hemispheric disk, spreading uniformly in every direction, without exhibiting the slightest tendency to bilateral symmetry. It is true that in Discophoræ the actinostome is apparently more complicated than in Ctenophoræ, because it is surrounded by long appendages hanging below the main cavity; but, notwithstanding this seeming superiority of development, it will be shown hereafter that the actinostome of the Ctenophoræ is in reality more highly organized than that of the Discophoræ, although the bulk of its appendages in the latter gives it a greater prominence. It is true also that in a large number of Discophoræ the margin of the disk is provided with numerous tentacles, but these tentacles are only peripheric diverticles of the chymiferous tubes, and in no way constitute a higher complication of that system than the vertical branches of the chymiferous tubes of the Ctenophoræ with their locomotive flappers. It is true also that the Discophoræ have distinct sexes, their ovaries and spermaries forming large bunches, in separate cavities, while the Ctenophoræ are hermaphrodites; but the special arrangement of the ovaries and spermaries in the latter, placed as they are on opposite sides of the vertical branches of the chymiferous tubes, contributes to render the complication of the structure of each individual more apparent in Ctenophoræ than in Discophoræ. It is true also that the Discophoræ have eight, and sometimes twelve or even more distinct eyes at the end of their radiating chymiferous tubes, while in Ctenophoræ there is a single eye at the abactinal pole; but then that single eye stands in direct communication with a special stem of the chymiferous system, occupying a central position in the axis of the body, while in Discophoræ there is one eye to each simple radiating tube.

Thus, whatever be the special combination of the organs in the Discophoræ proper, and however high they may appear to stand on account of the extraordinary development of some of their parts, the sum total of the structural complication in the Ctenophoræ is unquestionably greater than that of the Discophoræ. This will appear more distinctly, when we consider the similarity in general appearance of the Discophoræ to the naked-eyed Medusæ born from Hydroids. In this connection it must also be remembered, that, while the majority of Discophoræ enjoy only a consecutive individuality (see p. 97), since several Medusæ arise from the division of one single larva, in Ctenophoræ the reproduction takes place by a direct metamorphosis, each egg producing a single individual.

If multiplication of identical parts is everywhere an indication of inferiority, and definite numbers with definite relations a mark of superiority, Ctenophoræ will undoubtedly take the lead in that respect also over the Discophoræ, in which repetition of identical parts prevails, without a perceptible difference in their relations; while in Ctenophoræ the number of spherosomes never varies, and there exist between them such definite relations as simulate bilateral symmetry.

The Hydroids, as a whole, and considered within the limits assigned to that order in the preceding section, unquestionably occupy the lowest place in the class. For, in addition to the permanent character of indefinite repetition of identical parts, we observe among them, almost universally, a more or less characteristic polymorphism, sometimes to such an extent that it becomes difficult to distinguish secondary individuals from actual organs. Individuality is almost lost in the dependence in which the members of a community stand toward each other. Even when individuality becomes most prominent, it is so in individuals which are short-lived, in comparison to the duration of the combined individuals to which they owe their existence.

That the Discophoræ proper constitute a distinct order by themselves, appears plainly from the higher complication of their structure when compared to that of the naked-eyed Medusæ. In the latter, the radiating chymiferous tubes are all alike, equally distant one from another, simple, and either few or very numerous, and meet with a simple circular tube, instead of forming a complicated network of anastomoses along the margin of the disk, as in the Discophoræ proper, whose radiating tubes are alternately more or less complicated in their course, some extending as straight tubes to the margin of the disk and communicating with the base of the eyes, while others branch in various ways, and end in a network of anastomoses at the margin. In Discophoræ proper, there exist always highly organized eyes, in definite number, and these eyes are always placed at the marginal end of some specially organized radiating tube, alternating with other tubes of a different character; thus exhibiting a higher complication of these parts, not only in their structure, but also in the definiteness of their relations to one another, in their alternation with one another, and in their numeric limitation. Some Discophoræ have no other marginal organs besides eyes; but there are those that are provided with variously combined tentacles also: in none, however, are the eye-specks connected with tentacles, though the eyes are themselves modified tentacles.

In the naked-eyed Medusæ, the ovaries and spermaries follow the track of the radiating chymiferous tubes, and are variously circumscribed in their extent: in some, they are limited to the walls of the proboscis, in others they extend all along the chymiferous tubes proper, and in others they occupy only a part of the course of these tubes; but they are never circumscribed within distinct pouches, as in the Discophoræ proper. In these, the ovaries and spermaries bear identical homological relations to the chymiferous tubes, as far as their position is concerned; but, owing to their higher development and to their isolation, they form distinct bunches, hanging in distinct pouches on the lower side of the disk, and stand in definite relations to the parts surrounding the actinostome, through which the eggs are laid, while in the naked-eyed Medusæ the eggs simply drop from the ovary into the water without ever passing through the actinostome. Imperfect and injured specimens may leave a different impression respecting the mode of escape of the eggs from the ovaries; but I shall show hereafter that these egg pouches are really closed, and do not naturally open outward, as Ehrenberg represents them, but communicate only with the main cavity of the body, and through it with the actinostome, through which the eggs or the young finally make their escape into the water, after having remained for a longer or shorter time suspended in the peripheric folds of the actinostome.

In Discophoræ proper, the actinostome is far more complicated than in the naked-eyed Medusæ. In the latter, it is only a projecting fold of the lower wall of the spherosome, either extending simply as a circular rim beyond the main cavity, with or without fringes, or forming a more or less elongated proboscis. In Discophoræ proper, the actinostome is as it were suspended between distinct pillars hanging from the spherosome, which expand into more or less complicated leafy folds, the edges of which are either free, as in Aurelia, Pelagia, Cyanea, etc., or partially soldered together, as in Rhizostoma, Polyclonia, etc., thus forming either open or partially closed channels leading from their peripheric termination to the main cavity, which is itself wide and capacious, and supported laterally by the pillars of the actinostome. The cavities formed by the leafy folds of the actinostome are so far distinct from the main cavity, that they only communicate with it through the channels extending along the centre of these folds; while in the naked-eyed Medusæ the actinostome opens broadly into the main cavity. The chymiferous tubes arise from the upper part of the sides of the main cavity.

It thus appears that the Discophoræ proper have a far more complicated structure than the naked-eyed Medusæ, and that, in a natural classification, they cannot therefore be united into one and the same order, as has thus far been done by most naturalists. Moreover, the Discophoræ resemble one another very much in their general appearance and in their motions, which are effected by a slow alternate expansion and contraction of the disc.

The Hydroids, as the lowest order of the class of Acalephs, are far more diversified among themselves than either the Ctenophoræ or Discophoræ.[1] In the first place we find among them simple Hydroids, in the next place more or less medusoid Hydroids, then communities of variously combined individuals with more or less medusoid or hydroid characters; and among these communities there are

[1] It is a striking fact, conflicting with all preconceived ideas, that throughout the animal kingdom, the lower types, in every class, are far more diversified than their higher representatives. It is so among Polyps, if the Actinoids are inferior to the Halcyonoids; it is so again among the Actinoids, if the Madrepores are the highest among them. It is so among the Acalephs, if the Ctenophoræ are the highest and the Hydroids the lowest. It is so among Echinoderms, if the Holothurians stand highest and the Crinoids lowest. It is so among Acephala, if the Bryozoa belong to that class. It is so among Gasteropods, if the Pulmonates are superior to the Branchiates. It is so among Cephalopods, if the Dibranchiates deserve to be placed above the Tetrabranchiates. It is so among Worms, if the Helminths belong to the same class with the Annelids. It is so among Crustacea, if Rotifera and Entomostraca are their lowest representatives. It is so among Insects, if the Myriapods and Arachnids are united into one class with the Insects proper; and it would still be so if the winged Insects were considered as a class by themselves, for the madibulate Insects are more numerous and more diversified than the sucking Insects, and those which undergo the most complete metamorphoses fewer and less diversified than those whose metamorphoses are less complete. It is so among Fishes, if the bony Fishes are inferior to the Selachians. It is so among Amphibians, if the caudate Amphibians are inferior to the Frogs and Toads. It is so among Reptiles proper, if the Chelonians deserve the highest, and the Ophidians the lowest, place in that class. It is so among Birds, if the Palmipeds are their lowest representatives. It is so among Mammalia, if we contrast the Marsupials with the higher Mammalia; or if, among the latter, we compare the Rodents with the Human family. Of course, this greater diversity does not involve respectively greater differences among the lower representatives of any class when compared to one another, than among the highest; since their very inferiority, combined with great diversity, renders the possible amount of difference among the many lower ones less than among the fewer more highly organized ones. This very extraordinary diversity among the lowest types of all the classes of the animal kingdom stands in flagrant contradiction with Darwin's theory of the origin of species, according to which the lowest types should gradually give way to higher and higher types, in consequence of the struggle for life.

those which produce free Medusæ, and others which do not; some which consist entirely of Hydræ, and others of combined Hydræ and Medusæ; some start from Hydræ, others from Medusæ, — the communities themselves consisting either of a larger number of Hydroids, or of a larger number of Medusæ, when the two types are combined. These various combinations lead naturally to the formation of subordinate groups among Hydroids. Considering the mode of reproduction of the Acalephs in general, the highest Hydroids would, of course, be those in which the medusoid elements prevail, and the lowest, those in which the hydroid elements are most prominent. We have, therefore, to inquire first whether there are any genuine naked-eyed Medusæ which do not originate from Hydræ, in order to answer a question already raised respecting the true limits of the order of Hydroids, and the true position of the Æquoridæ and Æginidæ.

There are Æginidæ, unquestionably, which undergo a direct metamorphosis, and it is probable that this is the case with all of them. But are the Æginidæ genuine naked-eyed Medusæ, or a low type of the Discophoræ allied to the Charybdeidæ? My knowledge of this family is too limited to enable me to speak confidently upon that point; but I am inclined to consider them as belonging rather to the Discophoræ proper than to the Hydroids. In the first place the Æginidæ have no radiating chymiferous tubes, as all true naked-eyed Medusæ have; but instead of them there arise broad, flat pouches from the main cavity, extending toward the margin of the disk, as in Ephyra, the young of Aurelia and Cyanea, and as in the adult of the latter and of many other genera of Discophoræ proper. The Æginidæ have no circular chymiferous tube, as all true naked-eyed Medusæ have. Again, the tentacles of the Æginidæ are not strictly marginal, and, in the absence of a circular tube, cannot be closely connected with it as is the case in all true naked-eyed Medusæ, but are in direct communication with the radiating pouches of the main cavity, as in Pelagia and Cyanea. If, then, for these reasons, the Æginidæ should be associated with the higher Discophoræ, instead of occupying a place among the naked-eyed Medusæ, the importance attached by Gegenbaur to the marginal seam of the umbrella, as a distinctive character of the lower Discophoræ, would be greatly lessened; and I rather think rightly so, for many of the higher Discophoræ, and among them our common Aurelia, have the margin of their umbrella not only very thin, but turned inward and downward as in all Craspedota, and their tentacles arise between indentations of the disc (Pl. VII. *Figs.* 2, 3, and 4; Pl. VIII. *Fig.* 5, and Pl. IX. *Fig.* 4), at some distance from its margin, as is the case in the Æginidæ.

As to the Æquoridæ, I have no doubt that they are genuine Hydroids, though I have not been able to trace with certainty the origin of the Æquorea of our coast to any true Hydroid. But the structure of Æquorea, in its adult

Medusa state, is so strictly homologous to that of all other naked-eyed Medusæ, that, even if it were ascertained that it undergoes a direct metamorphosis from the egg to the perfect Medusa, I would not hesitate to consider it as a member of the order of Hydroids, since it has simple radiating chymiferous tubes, a circular tube, and marginal tentacles closely connected with it, and provided with mere pigment specks upon their base.

It will require a more extensive knowledge than we now possess of the development of all Hydroids, before the relative standing of their various types can definitely be ascertained. As far as our information goes, the rank of Hydroids among themselves does not seem to be determined primarily by the production of free Medusæ, since Campanulariæ produce free Medusæ; while among Tubulariæ we have those which bring forth free Medusæ, and others which do not. The distinctness of the medusoid and hydroid elements, without reference to the liberation of the Medusæ, seems more significant; for, unquestionably, a Physalia with its extraordinary polymorphism has an organization inferior to that of a Sarsia born from a Coryne. In the first case we have a very complicated community, it is true, but it consists chiefly of low, heterogeneous elements variously combined, and the Medusæ buds themselves are of the simplest kind, and without tentacles; while in the second case the hydroid and medusoid elements are quite distinct, and the Medusæ arising from the simple Hydrarium are as perfect as any other naked-eyed Medusæ. The same may be said of Lizzia, Hippocrene, and Hybocodon, all of which have a limited and definite number of radiating chymiferous tubes, a limited and definite number of tentacles or bunches of tentacles, all characters which seem to assign to them a marked superiority over Tiaropsis and Thaumantias with their numerous marginal tentacles which arise from Campanulariæ, that is, from Hydroids exhibiting already signs of polymorphism, while the Hydraria from which Sarsia, Lizzia, etc., arise, consist only of one kind of Hydræ.

It would thus appear that the distinctness of the hydroid and medusoid elements in this order is inverse to the polymorphism of their communities. The Medusæ buds of most Siphonophoræ play a rather indifferent part in their economy; and yet their prominence coincides with the degree of complication of the hydroid and medusoid elements of their communities. Velella, the community of which consists only of two kinds of Hydræ, produces distinct free Medusæ; while the Diphyidæ and the Physophoridæ, in which the hydroid and medusoid elements are most completely mixed, are also those which are most remote from the true type of Discophoræ, and resemble most, in their mode of living, the free locomotive Polyp communities. But even as compound communities consisting of heterogeneous elements, it is remarkable that those in which the medusoid elements prevail are also the most active, while those in which the hydroid elements are predominant, are more floating than active. A comparison between Porpita, Velella, and Physalia on one side, and the Diphyidæ and Physophoridæ on the other side, cannot fail to convince any one who has seen any of these animals alive of the truth of this general statement. When describing, in the sequel, the North American Hydroids in detail, I shall have an opportunity of showing that the subdivisions founded upon the differences here noticed among these animals are genuine sub-orders, and neither orders nor families.

Though I have not the remotest doubt that the Tabulata (*Figs.* 81 and 82) are genuine Hydroids, I am not quite so confident that the Rugosa (*Fig.* 80) also belong

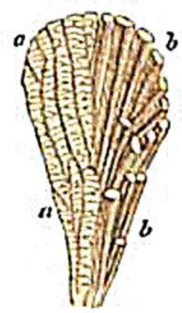
Fig. 80.

GONIOPHYLLUM PYRAMIDALE,
(*Copied from M.-Edwards & Haime.*)
Upper figure, view from above; lower figure, profile. Fossil of the Silurian period. Comp. Lucernaria, p. 111, *Figs.* 75 and 76.

Fig. 81.

MILLEPORA ALCICORNIS, Lmk.
Transverse section of a branch of the Coral stock, magnified.
a a Pits of the Hydroids, with their successive floors. It is very difficult to obtain sections of the pits occupied by the smaller Hydroids.

Fig. 82.



BEAUMONTIA EGERTONI,
(*Copied from M.-Edwards & Haime.*)
Fossil of the Carboniferous period. It resembles so closely the living Pocillopores, that it certainly belongs to the same sub-order.

to this class. I have not had sufficient opportunity of studying the Rugosa anew, since I have known the acalephian affinities of the Tabulata, to feel justified in expressing a decided opinion upon that point. I will therefore simply present my reasons for believing that the Rugosa belong to the same class as the Tabulata. The cavity occupied by the animal is divided by horizontal floors, evidently built successively as in course of its growth the animal rose higher and higher, and these floors are continuous from wall to wall across the whole width of the cavity of the Coral; and wherever there exist radiating partitions, they rise only from the surface of these floors, without extending through them to any other floor above or below. No Coral known to be the solid frame of a Polyp has such a structure. On the contrary, in Polyparia the radiating partitions of the individual cavities occupied by distinct animals extend uninterruptedly from top to bottom of their cavities, and if there exist horizontal floors, these stretch only across the intervals between two radiating partitions, and never across the whole cavity occupied by the Polyp. The radiating partitions of the Rugosa, beside being limited to successive floors, present another striking peculiarity, never observed among the Polyps,—they are arranged in fours, or multiples of four. This quadripartite structure of the Rugosa is an acalephian feature, nowhere observed among true Polyps, but characteristic of Lucernaria, which is a genuine Hydroid Acaleph. I may also allude to a more remote argument for referring the Rugosa to the Acalephs. There are simple ones among them, and others forming rather loose communities, composed of comparatively few individuals; but, whether simple or combined, each individual of this type, with its successive floors, presents a striking resemblance to a Strobila. Rugosa, indeed, may be considered as a prototype of the Acalephs, combining the most characteristic embryonic features of the class with the simplicity and peculiarity of structure of its lowest type.

When considering the different orders of Acalephs singly, I shall show that their families are founded upon different patterns of form, their genera upon ultimate structural details, and their species upon the proportions of their parts, and the relations of individuals to one another and to the surrounding mediums. To introduce these topics here, would involve me in an amount of details, which are best referred to the special parts of this monograph.

Although an order in Zoölogy especially signifies the relative rank of the members of a class, as exhibited in the complication of their structure, it is not in the orders alone that we recognize different degrees and different kinds of superiority or inferiority. As I have already stated elsewhere (vol. 1, p. 152), groups of a more or less comprehensive value may exhibit a relative superiority or inferiority; nor is an order a natural group that has no other meaning but that which it derives from its higher or lower position. The primary branches of the animal kingdom do not all stand on a level: Radiates, as such, are unquestionably inferior to Mollusks or Articulates or Vertebrates, even though some Radiates may have a more highly complicated organization than some of the lowest Fishes. We assign to the Radiates a lower position than that of the other branches, because the elements of their plan of structure are of an inferior stamp; and we place the Vertebrates highest, because the plan of their structure is in itself the most complicated: but it would be difficult to weigh the different organic tendencies combined in either the Mollusks or Articulates so nicely as to prove that either of them is superior to the other, though, unquestionably, as primary divisions of the animal kingdom, they are superior to the Radiates and inferior to the Vertebrates. The idea of placing either the Mollusks or the Articulates immediately above the Radiates, so as to establish a gradual transition between them and the Vertebrates, seems entirely out of the question, since the most distinguished naturalists who have attempted to arrange the first primary divisions of the animal kingdom in a series have failed to produce convincing arguments in favor of the superiority of the Mollusks over the Articulates, or of the latter over the former. The fact is, there is quite as high authority for one as for the other position of these two branches. The most natural view seems to me to be that which assigns to them an equal standing, and recognizes their difference in the different tendencies of their plan; so that, taking the sum of their characteristics, the four primary branches of the animal kingdom should not be placed in one series. Their true relations seem to be best expressed by a diagram like this:—

VERTEBRATES,
MOLLUSKS,———————ARTICULATES,
RADIATES.

Again, the different classes of each branch show a relative superiority one above the other. Polyps as a class are certainly inferior to Acalephs as a class, and these, again, inferior to Echinoderms. Acephala as a class are unquestionably inferior to Gasteropoda, and these, again, inferior to Cephalopoda. Worms as a class are certainly inferior to Crustacea, and these in their turn inferior to Insects, etc. And yet there are Worms, such as the higher Annelids, in which the structural complication much exceeds that of the lowest Crustacea, such as the Rotifera. Some Lamellibranchiates are much more highly organized than some of the Phlebenterate Gasteropods. Some of the Fishes may be considered superior to some Batrachian Reptiles; but no Reptile seems to rise to a level with Birds. Here again we see, therefore, that difference of rank is only a secondary feature for classes. The same may be said of families and of genera, as well as of species, and it is much to be lamented that our language has not a greater variety of words to express the many shades of relative standing; so that we are limited to the almost exclusive use of the words *superior* and *inferior*, which are inadequate to render the comparative relations of beings in themselves so exquisitely organized as are the representatives of every class in the animal kingdom. In the groups called orders, however, the idea of superiority and inferiority seems to be the prevalent feature. Yet orders themselves exhibit also another kind of relations, to which I have already incidentally alluded in an article on the Categories of Analogy, added to the London edition of my Essay on Classification.[1] It is curious to observe how the views entertained by Oken[2] respecting certain affinities among animals, resulting, in his opinion, from the repetition of the same principle in groups of different value, loom up again in the relations of the orders of certain classes to other groups, to which they themselves do not belong.

If it be true that Hydroids, Discophoræ, and Ctenophoræ are three distinct orders among Acalephs, it cannot be overlooked, that, by their general appearance,

[1] Essay on Classification, by L. Agassiz, London, 1859, 8vo., pp. 271–284.

[2] Compare vol. 1, p. 211. See also OKEN'S Physio-philosophy, London, 1847, 1 vol. 8vo.

the Hydroids resemble the Polyps, with which, indeed, they have been united as members of the same class; while the Discophoræ proper constitute the characteristic group of Acalephs, the group which has always been considered the typical group of this class. The Ctenophoræ bear the same relation to Echinoderms as the Hydroids bear to the Polyps; and this resemblance of the Ctenophoræ and Echinoderms is especially recognizable in the peculiarity of their vertical chymiferous tubes with their locomotive flappers, and the homology there is between them and the ambulacral system of the Echinoderms. But neither the resemblance of Hydroids to Polyps nor that of Ctenophoræ to Echinoderms is a real indication of affinity: it is only an analogy, arising from a similarity of form in parts which have only a general homology, and no special homology with one another. But this analogy, once recognized, has its significance. It confirms the views presented above respecting the relative standing of the three orders of Acalephs. Hydroids, as the lower order of Acalephs, are analogous to the Polyps, the lowest class of Radiates; Discophoræ, the most characteristic type of Acalephs, occupy a middle position between them and the Polyps, as the Acalephs, considered as a class, occupy an intermediate position between the Polyps and Echinoderms; and the Ctenophoræ, as the highest order in the class of Acalephs, correspond to the Echinoderms, and especially to the Holothurioids, the highest order of the highest class among Radiates.

Such analogies may be traced in other classes of the animal kingdom. Assuming that the Articulates embrace only three classes, — the Worms, Crustacea, and Insects; and that the Insects themselves form only three orders, — Myriapods, Arachnids, and Insects proper, no one can fail to perceive the analogy between the Myriapods as the lowest order of Insects, and the Worms as the lowest class of Articulates, or between the Arachnids as the second order of Insects, and the Crustacea as the second class of Articulates; and the highest order among Insects consists of those best representing the character of the class of Insects, which stands highest among Articulates. Perhaps objections may be raised against this primary division of the Insects into three orders, and perhaps also against the division of Articulates into three classes; but to my mind these analogies would have great weight in establishing this classification as correct. Whatever may be said of the analogies alluded to between the orders of Acalephs and the classes of Radiates, I have no hesitation in affirming that there are only three orders in the class of Acalephs, and that these orders stand to one another in the position I have assigned to them, — the Hydroids being the lowest, the Discophoræ next, and the Ctenophoræ highest.

SECTION VIII.

SUCCESSION OF ACALEPHS.

Thirty-three years ago, while examining the Museum of the Grand Duke of Baden, in Carlsruhe, my attention was attracted by two slabs of limestone slate from Solenhofen, the counterparts of one another, upon which a perfect impression of a Discophorous Acaleph was distinctly visible. The impression made upon my mind by the preservation, through countless ages, of an animal so soft as a jelly-fish, was so vivid, that, though I have never seen those fossils since, I well remember their general appearance. I regret the more, however, that I did not at the time make a sketch of them, since to this day they have remained undescribed; and, so far as I know, no allusion to genuine fossil Acalephs is to be found anywhere except in the first volume of this work (p. 24), where I mention the occurrence of Medusæ in the limestone of Solenhofen as indicative of the earliest period of the existence of that class upon earth. At the time I saw these fossils, our knowledge of the Acalephs was very scanty; few good illustrations existed; and the works of Eschscholtz and his followers had not yet been published: so that, had I even been conversant with every thing then known about this class of animals, I could not have determined to what family they belonged. I earnestly hope that some of the German naturalists, who of late have so largely contributed to the advancement of our knowledge of that class, may be induced by this notice to hunt up those fossils, and publish an accurate description of them with good illustrations, that their close affinity to the numerous families now distinguished among Acalephs may be ascertained. It is now a matter of great importance, for it may afford indications of the connection between the living types of Acalephs and their oldest representatives on earth; since it has been ascertained that certain Coral stocks, a large number of which occur in the Palæozoic rocks, called Tabulata by Milne-Edwards, and thus far referred to the class of Polyps, are genuine Hydroid Acalephs, while a comparison of another type of Corals, called Rugosa by Milne-Edwards, with the Tabulata, makes it highly probable that they also are Acalephs, rather than Polyps.

As shown before, the Tabulata, unquestionably, are Hydroids. Direct evidence to that effect has been obtained by an examination of the animal of Millepora; and as all the other Tabulata, both living and fossil, have the same structure of their solid Polyparium as Millepora, it is evident that the whole group must be considered as essentially acalephian. As far as the Polyparium of the Rugosa is concerned, the evidence of their acalephian nature is hardly less strong than that adduced for the acalephian affinities of the fossil Tabulata. The only difference in the evidence is, that for the Tabulata we have the confirmation of these affinities in the structure of the animal of one of their living members, while that evidence is wanting for the Rugosa. But, as I have already stated, the Coral stock of the Rugosa coincides so far with that of the Tabulata, that it is built up with successive floors, extending uninterruptedly across the bottom of the whole cavity, which was evidently occupied by the animal; while the Coral stock of all genuine Polyps presents radiating partitions extending uninterruptedly from top to bottom of the cavity occupied by the animal, and the horizontal floors that may exist, stretch only from one of these radiating partitions to the other.

Now, if both Rugosa and Tabulata are Acalephian Corals, it is very desirable that correct views of their affinities with the other Acalephs should be obtained, in order to arrive at correct conclusions respecting the order of succession of the Acalephs in past geological times, and of their connection, through the only known fossil Discophorous Medusa, with the living representatives of the class.

Scanty as is our information of the fossil Acalephs beyond the knowledge of the order of the succession of the Rugosa and the Tabulata, it is already highly interesting, even with these imperfect data, to institute comparisons between all the members of the class respecting their order of succession. We have seen that the Ctenophoræ are the highest order of Acalephs, and that the Discophoræ proper are next to these in standing; while the Hydroids, including the naked-eyed Medusæ and the Siphonophoræ, constitute the lowest order of the class. We have seen, further, that among the Hydroids themselves, those in which the medusoid elements prevail over the hydroid elements should be considered as the superior ones. Taking, now, the only indication we have in Millepora as our guide to an appreciation of the standing of the Tabulata among the Hydroids, it is plain, from the circumstance that these Hydræ communities form large, permanent Coral stocks, living probably for centuries, that they have a character of inferiority as contrasted with the short-lived Hydro-Medusaria, and especially with those which produce free Medusæ in alternate generations. But if the Tabulata stand low in the lowest order of Acalephs, we have in this fact a striking coincidence with the character of the representatives of other classes in earlier periods. Since Crinoids prevail in Palæozoic times, while free Star-fishes and Echinoids make their appearance later; — since Bryozoa and Brachiopods prevail during the same old periods, while Lamellibranchiates become prominent in later geological epochs; — since Trilobites are the earliest Crustaceans, followed by gigantic Entomostraca, and higher Crustacea appear only in the middle geological ages, etc., etc., we should expect that Acalephs also should make their appearance with the representatives of their lowest order; and we have just seen that the Tabulata occupy an inferior position in that lowest order.

Assuming that Rugosa are Hydroids also, the question of their standing in their order is not difficult to determine, if we take into consideration the general character of the class, and its relations both to the class of Polyps and to that of Echinoderms. I have already alluded to the analogy between the Hydroids and the Polyps, and to that between the Ctenophoræ and Echinoderms. Starting from this fact, let us see what are the elements of superiority and inferiority among the Radiates, at the two ends of the type. In Polyps we distinguish two orders, the Actinoids and the Halcyonoids. Taking their whole structure into consideration, the Actinoids with their simple tentacles and the indefinite repetition of similar parts in most of them, are, unquestionably, inferior to the Halcyonoids with their eight-lobed tentacles and invariable eight spheromeres. Now, among Halcyonoids there are no simple individuals: all the types of this order consist of compound communities, while among the Actinoids we have both simple individuals and compound communities. But here again it is among the compound communities that we find the higher organic combinations: for certainly the Madrepores, with their twelve tentacles, alternately larger and smaller, are superior to the Astræoids, and these again superior to the Actinioids; and that these latter are the lowest will hardly be doubted, if we consider the absence of solid deposits in them, and the equally characteristic absence of horizontal floors between their radiating partitions. It will be conceded also that the Fungidæ stand next above them, since they have a large number of tentacles, like the Actiniæ, and only transverse beams extending from one radiating partition to the other, instead of continuous floors as in the Astræoids, which stand above them on that account, as well as on account of their limited number of tentacles. The Madrepores, unquestionably, are the highest among the Actinoids, since they not only present a limited number of tentacles, but a number which is always constant, and, in addition to this, another higher combination of structural features, arising from an alternation of larger and smaller tentacles and a marked one-sidedness of their calycles.

It is thus plain that the gradation among Actinoids,—that is, the higher and higher rank they occupy when compared with one another,—stands in direct ratio to their complication and to their combination into communities, and in an inverse ratio to their individual independence. The simple Polyps, such as Actiniæ, are the lowest; the Fungidæ, among which there are simple types, such as the genus Fungia proper, are next in rank; the Astræoids and allied families, which form always compound communities, with a reduced but more definite number of tentacles, come next; and the Madrepores, forming among the Actinoids the most complicated communities, stand highest.

There is still another feature among Polyps, which ought to be considered in this connection. Not only do the Halcyonoids, the higher order among Polyps, form compound communities in all their representatives, but we find that these compound communities tend to acquire a marked individual independence, which is fully reached in those types of this order which, like Veretillum, Renilla, and Pennatula, move about freely, and these are the highest among the Halcyonoids. A similar tendency to individualization of communities is also observed in the highest Actinoids; for some Madrepores not only form complicated communities, but exhibit, at the top of their branches, an individual which, though forming part of the community, is larger than all the lateral individuals, and gives, as it were, individuality to each branch.

With these facts before us, it will not be difficult to determine the relative standing of the Rugosa and Tabulata. The Rugosa differ from the Tabulata in having a considerable number of representatives which are simple individuals; or, when they form communities, these are a loose aggregation of a few individuals maintaining a certain degree of independence: we never find among them communities formed of innumerable closely combined individuals, such as occur among Tabulata, in many of which there exists a direct communication between adjoining individuals through pores in their walls. I am, therefore, inclined to consider the Rugosa as inferior to the Tabulata; and their prevalence in the oldest rocks and their early extinction in geological times, while Tabulata are continued to this day, confirm this view. The Rugosa seem to me to stand in the same relation to the Lucernarioids among Hydroids, as the Actiniæ stand to the Fungidæ among genuine Polyps. And here, again, we have a remarkable analogy between the two types, in the circumstance that Fungidæ are the oldest genuine Corals known, as the Rugosa are the oldest type among Hydroids.

All this is in perfect accordance with the character of the higher Acalephs. As we have seen before, the Ctenophoræ are analogous to Echinoderms; but Echinoderms have reached a degree in organic complication in which individuality, as such, becomes a character of superiority. In conformity with this analogy, we find that all Ctenophoræ are free individuals, and so are the Discophoræ also; while the free naked-eyed Medusæ arising from Hydroids occupy, in that respect, an intermediate position between the higher Acalephs and the lower Hydroids, which form large and highly complicated communities, and bear, in their perfect state, sessile Medusæ buds only. I do not see that any objection can be made to the rank here assigned to the Acalephs in general. It seems to me to be determined by their whole structure, as well as by their mode of development, and must be considered as the true expression of their natural affinities, if the lowest Hydroids are those in which the hydroid elements prevail over the medusoid elements, and if free Medusæ born from Hydroids are inferior to the Discophoræ proper, and these, again, inferior to the Ctenophoræ. It is certainly a most striking circumstance, that the only fossil free Acalephs known should be a Discophorous Medusa, for it is the type we should naturally expect to follow Hydroids in course of time, when it has once been ascertained that the earliest representatives of all classes are either the lowest of their type, or embryonic in their character or synthetic in the complication of their structure, as I have shown in the first volume of this work (pp. 107–122).

Some general remarks upon the geographical distribution of the Acalephs should naturally find a place here; but it is so indispensable to a true appreciation of the mode of distribution of animals, that their types should be correctly referred to their respective natural divisions, that, before considering the classification of the Acalephs in its details down to the genera and species, no accurate picture of their geographical range and mutual relations in space can fairly be presented. I must, therefore, postpone the consideration of this subject to another part of this monograph, when, in addition to the information already collected, I shall be able to avail myself of the investigations made by my son upon the Acalephs of the Pacific coast of North America. It is a matter of great interest to me thus to have the means of comparing critically the Acalephs of the temperate zone, not only of the two sides of the Atlantic, but also of the Pacific, and to be able to complete, in a measure, the statements of Brandt relating to the Discophorous Medusæ collected by Mertens, most of which were described, after his death, from the drawings made by the naturalists of the Seniavin.

SECTION IX.

CLASSIFICATIONS OF ACALEPHS.

The improvements in the classification of the Acalephs have been the consequence of a gradual and successive expansion of the boundaries of that class, resulting from the recognition of Acalephian characters in animals at first not suspected to be at all related to them. The class, as such, has not been at once recognized as a natural group, in consequence of the want of such a striking similarity of its members, as is observed, for instance, among Birds or Insects; but it has grown by successive additions, forced, as it were, by internal evidence upon the notice of naturalists, and slowly acquired, at long intervals, by laborious, successive steps. However, the very character of this gradual progress renders the study of the classifications of Acalephs the more interesting to the philosophical student; and a comparison of these different arrangements may teach us how to proceed in our attempts to improve the classification of animals generally.

Though, from the beginning of his brilliant career, Cuvier had turned his attention to the study of the Acalephs, and published his anatomy of Rhizostoma long before the "Règne animal" appeared, his "Tableau élémentaire," published in 1798, contains nothing of importance upon these animals. It was Lamarck who took the lead in their systematic arrangement.

CLASSIFICATION OF LAMARCK, 1801 and 1816.

In his "Système des Animaux sans Vertèbres," published in 1801, Lamarck unites the Acalephs and Echinoderms in one and the same class under the name of Radiaires, separating them, however, as two distinct orders of that class, as *Radiaires Echinodermes* and *Radiaires Mollasses*. The second order, which corresponds to the Acalephs, embraces the following genera: Medusa, Rhizostoma, Beroe, Lucernaria, Porpita, Velella, Physalia, Thalis, and Physophora. The Hydroids proper are referred to the class of Polyps. In proposing this arrangement, Lamarck made the first step towards recognizing the natural limits of the class of Acalephs.

In the "Histoire naturelle des Animaux sans Vertèbres," published from 1815 to 1822, he adopts the same general classification of these animals; but subdivides the Acalephs in the following manner:—

1st Section. Radiaires Anomales:—1° Stephanomia. 2° Cestum, Callianira, Beroe, Noctiluca, Lucernaria. 3° Physophora, Rhizophysa, Physalia, Velella, and Porpita.

2d Section. Radiaires Médusaires:—1° Eudora, Phorcynia, Carybdea, Æquorea, Callirhoe, Dianea. 2° Ephyra, Obelia, Cassiopea, Aurelia, Cephea, Cyanea.

The classification of Lamarck is evidently based upon a mere general appreciation of the relationship of the animals considered by him in detail. Comparative anatomy was not yet sufficiently advanced to furnish definite characteristics of the different groups adopted by the systematic writers of that period. The reunion of the Acalephs and Echinoderms as one class, for instance, is undoubtedly a great exaggeration of their affinity; but it marks, nevertheless, an important progress in the natural history of the lower animals, since such a combination could only be proposed by one who had already freed himself, at least partially, from the impression that the presence or absence of a solid frame was an essential character of these animals, and who began to perceive that the plan of structure, or at least the degrees of complication of that structure, was of higher importance, in a natural classification, than such secondary features. In this connection, it is important to remember that Lamarck was one of the naturalists who knew the Echinoderms best, and that he never could have united the Medusæ with them, had he not perceived the structural relation which forever will unite into one and the same great division such animals as Aurelia and Scutella.

The naturalists who have known the Acalephs best during the first quarter of this century are unquestionably Péron and LeSueur, and their publications are, to this day, among the most important upon all the members of this class, with the sole exception of the Hydroids.

CLASSIFICATION OF THE MEDUSÆ PROPER BY PÉRON AND LESUEUR, 1809.

Though Péron and LeSueur have contributed, more extensively than any other naturalists of the beginning of this century, to the advancement of our knowledge of the Acalephs, their systematic efforts were limited to the classification of the Medusæ proper, of which they have published the following diagram in the 14th vol. of the Annales du Muséum, 1809, 4to.:—

Première division. Méduses agastriques.
- *a.* Non pédonculées.
  - + Non tentaculées. Eudora.
  - ++ Tentaculées. Berenix.
- *b.* Pédonculées.
  - + Non tentaculées. Orythia, Favonia.
  - ++ Tentaculées. Lymnorea, Geryonia.

Seconde division. Méduses gastriques.

Première section. Gastriques monostomes.
- *a.* Non pédonculées.
  - + Non brachidées.
    - ⊕ Non tentaculées. Carybdea, Phorcynia, Eulimenes.
    - ⊕⊕ Tentaculées. Æquorea, Foveolia, Pegasia.
  - ++ Brachidées.
    - ⊕ Non tentaculées. Callirhoe.
- *b.* Pédonculées.
  - + Non brachidées. Non représentées.
  - ++ Brachidées.
    - ⊕ Non tentaculées. Melitea, Evagora.
    - ⊕⊕ Tentaculées. Oceania, Pelagia, Aglaura, Melicerta.

Seconde section. Gastriques Polystomes.
- *a.* Non pédonculées.
  - + Non brachidées.
    - ⊕ Non tentaculées. Euryale, Ephyra.
    - ⊕⊕ Tentaculées. Obelia.
  - ++ Brachidées.
    - ⊕ Non tentaculées. Ocyroe, Cassiopea.
    - ⊕⊕ Tentaculées. Aurelia.
- *b.* Pédonculées.
  - + Non brachidées.
  - ++ Brachidées. Non représentées.
    - ⊕ Non tentaculées. Cephea, Rhizostoma.
    - ⊕⊕ Tentaculées. Cyanea, Chrysaora.

The peculiar form of the diagram of Péron and LeSueur recalls the character of the classifications generally adopted in France at the time of its publication, consisting in dichotomic divisions and subdivisions, providing even for the position of unknown representatives of the methodical framework, and exhibiting more ingenuity than insight into the nature of true classifications. The chief object naturalists had in view in devising such arrangements was rather to facilitate the identification of genera and species, than to ascertain their natural relations. At that time Cuvier had not published his views upon classification; so that the idea of the subordination of characters, so fruitful in important results, did not yet pervade the systematic works of the beginning of this century.

It is much to be regretted, that the very extensive investigations of Péron and LeSueur, and the many admirable drawings of Acalephs made from nature by the latter during his travels in every part of the world, should have been but partially published, and should have remained unknown to most naturalists outside of France.

CLASSIFICATION OF THE SIPHONOPHORÆ BY LESUEUR.

Lesson, in his "Histoire naturelle des Zoophytes, Acalèphes," has published a classification of the Siphonophoræ by LeSueur, the original of which I have been unable to obtain. LeSueur calls these animals Radiaires mollasses composés, and divides them in the following manner:—

1st Group. *Isolated*: 1° Porpita and Velella. 2° Rhizophysa and Physalia.
United: 1° Physophora and Stephanomia. 2° Protomedea and Amphiroa.

From the place this paper occupies in Lesson's account, I am induced to believe that it must have been drawn up about the time of the publication of the classification of the Medusæ proper by Péron and LeSueur.

Cuvier's influence upon the progress of the natural history of the Acalephs is not to be measured by the amount of special information he has contributed to the stock of our knowledge of these animals, but rather by the spirit he has infused into the study of Natural History. His recognition of the four primary groups of animals, based upon four different plans of structure, not only justified the separation of the Acalephs as a class, but established at the same time their true relation to the Echinoderms and Polyps in one great natural division: and though Cuvier made the mistake of uniting with them the Helminths and Infusoria, on account of the simplicity of their structure, he nevertheless disclosed the principle upon which their classification is finally to be settled; and the mistake he made on that occasion was only the result of his own departure from that very principle, when he allowed the consideration of the simplicity of the structure of the Intestinal Worms and of the Infusoria to overrule that of the plan of their structure.

CLASSIFICATION OF CUVIER, 1817 and 1830.

It was Cuvier who first separated the Acalephs as a distinct class, in the first edition of the "Règne animal," published in 1817. There he divides these animals into three orders, as follows:—

1st Order. FIXED ACALEPHS:—Actinia, Zoanthus, Lucernaria.

2d Order. FREE ACALEPHS:—Medusæ: Medusa, Æquorea, Phorcynia, Foveolia, Pelagia; Cyanea, Rhizostoma, Cassiopea: Geryonia, Lymnorea, Favonia, Orythia, Berenice, Eudora; Carybdea; Beroe, Callianira, Cestum;—Diphyes;—Porpita, Velella.

3d Order. HYDROSTATIC ACALEPHS:—Physalia, Physophora, Rhizophysa, Stephanomia.

The Hydroids are referred to the class of Polyps; and some genuine Polyps, Actinia, and Zoanthus are ranked among the Acalephs.

In the second edition of that work, published in 1830, Cuvier, excluding now the Actiniæ from this class, but still leaving the Hydroids out of consideration, admits the following arrangement for the genuine Acalephs:—

1st Order. SIMPLE ACALEPHS:—Medusa, Æquorea, Pelagia, Cyanea, Rhizostoma, Cephea, Cassiopea.—Astomes: Lymnorea, Favonia, Geryonia, Orythia, Berenice, Eudora.—Carybdea.—Beroe, Idya, Doliolum, Callianira, Janira, Alcinoe, Ocyroe, Cestum.—Porpita, Velella.

2d Order. HYDROSTATIC ACALEPHS:—Physalia, Physophora, Hippopus, Capulites, Racemides, Rhizophysa, Stephanomia.—Diphyes, Calpe, Abyla, Cuboides, Navicule.

A glance at the works of Schweigger is sufficient to satisfy any one that his investigations are to be valued chiefly for their minuteness and accuracy, and that his systematic arrangement of the lower animals is not the result of matured principles, or deep insight into their affinities.

CLASSIFICATION OF SCHWEIGGER, 1820.

Schweigger was one of the naturalists who knew the soft-bodied Invertebrates best, during the first quarter of this century. In his extensive journeys on the coast of the Mediterranean, he had collected vast stores of materials to illustrate their natural history, and his "Handbuch der Naturgeschichte der skelettlosen ungegliederten Thiere, Leipzig, 1820, 1 vol. 8vo." is chiefly based upon original investigations; wherefore I allude to it here, even though he has done nothing to improve the classification of the Acalephs: but he gives the best summary of their structure for that period. The animals now included in the type of Radiata are referred by him to three classes,—the Zoophytes, the Acalephs, and the Radiata; and under the last name the Echinoderms are combined with Actinia, Zoanthus, and Lucernaria. To the Zoophytes he refers the Hydroids and Polyps, with which he also associates Infusoria; but he judiciously removes from them the Ascidians, which he considers as Mollusks. The Crinoids he rightly regards as Echinoderms allied to Comatula, and the Corallinæ as Algæ.

The Acalephs are arranged nearly as in the system of Lamarck.

I. Stephanomia—Physophora—Physalia, Velella, Porpita—Cestum, Callianira, Diphyes, Beroe, Noctiluca.

II. *Medusa*, *Lin.*, and subdivided as in Péron and LeSueur.

Goldfuss was one of the most eminent zoölogists of the German school of Physio-philosophers. Adopting the general view of Oken, that the animal kingdom is an organic whole, representing as it were the individualized parts of the highest living beings, he considers the classes and their subdivisions as determined by the nature of the organs through which animal life is maintained. In the special parts of his Text-book he displays an extensive acquaintance with the whole animal kingdom, and suggests many important improvements over the classifications of his predecessors. His arrangement of the Acalephs especially, discloses a better appreciation of their affinities than any previous system.

CLASSIFICATION OF GOLDFUSS, 1820.

In his "Handbuch der Zoologie," published in 1820, Goldfuss unites into one class, under the name of Protozoa, the following groups of animals, which he considers as orders of that class: 1° Infusoria, 2° Phytozoa, 3° Lithozoa, 4° Medusinæ. This fourth order embraces the Acalephs proper, which are divided into the following families:—

1st Family. ÆQUOREÆ: Eudora, Ephyra, Æquorea, Orythia, Oceania, Cephea, Pelagia, Cassiopea, Callirhoe.
2d Family. BEROES: Idia, Beroe, Cestum, Callianira.
3d Family. PHYSOPHORÆ: Rhizophysa, Physophora, Stephanomia, Arethusa.
4th Family. PORPITÆ: Porpita, Velella.

The Hydroids are divided among the orders Infusoria and Phytozoa, and the Corallinæ and Crinoids among the Lithozoa. The separation of the Beroes and Porpitæ from the Medusæ proper is a marked improvement over the classification of Cuvier.

As naturalist of the expedition of the Rurick around the world, Chamisso had excellent opportunities for studying the Acalephs, and his special investigations of many new forms are truly valuable. His paper upon Salpa, also the result of this voyage, is the most important contribution of the poet-naturalist to the advancement of science. In working up his materials relating to the Acalephs, he was assisted by his friend Eysenhardt, himself the author of an excellent paper upon the anatomy of Rhizostoma.

CLASSIFICATION OF CHAMISSO AND EYSENHARDT, 1821.

MEDUSÆ. Vesiculares: Physalia, Physophora, Rhizophysa.
Medusæ proper: Rhizostoma, Cephea, Pelagia, Cyanea, Aurelia, Æquorea.
Vibrantes: Beroe, Callianira, Cestum, Appendicularia.
Chondrophoræ: Velella, Porpita.
Anomalæ: Diphyes, Stephanomia.

This classification is a mere reproduction of that of Goldfuss, with a change of names and an injudicious separation of Stephanomia and Diphyes from the other Siphonophoræ.

Were not Latreille the first entomologist of all ages, and had he not shown himself a master in describing species, characterizing genera, defining natural families, and improving generally the classification of Insects, it would hardly be worth our while to consider his attempt at classifying the Acalephs. But this attempt of his may serve as a warning against the temptation, too frequently indulged by eminent men, to express opinions upon matters with which they are not familiar, or to cover their ignorance by an easy display of high-sounding but empty words. On looking at the diagram of Latreille's classification of the Acalephs, it might seem, at first sight, that he presents in it a new and original arrangement of these animals. The names *Poecilomorpha* and *Cyclomorpha*, with which he designates the two orders into which the class is divided, are certainly new to science, but they are utterly useless and superfluous, inasmuch as they neither represent a new view nor a new combination in the classification of these animals, and are in no way better than those which had already been proposed by Lamarck and Cuvier for the very same division. The limitation of the families is, if possible, worse, and the names applied to them are liable to the same objections as those of the orders.

CLASSIFICATION OF LATREILLE, 1825.

The views of Latreille upon the affinities of the Acalephs were published in his "Familles naturelles du Règne animal," Paris, 1825, 1 vol. 8vo. Adopting the class of Acalephs as circumscribed by Cuvier, he divides them into two orders and six families.

1st Order. POECILOMORPHA, corresponding to the Radiaires Mollasses Anomales of Lamarck, exclusive of Lucernaria.

- 1st Family. **Ciliata**: Beroe, Callianira, Cestum, Diphyes.
- 2d Family. **Papyracea**: Porpita, Velella, Noctiluca.
- 3d Family. **Hydrostatica**: Physalia, Physophora, Rhizophysa, Stephanomia.

2d Order. CYCLOMORPHA, corresponding to the Radiaires Mollasses Médusaires of Lamarck.

- 1st Family. **Monocotyla**: Medusa, Æquorea, Foveolia, Phorcynia.
- 2d Family. **Polycotyla**: Cyanea; Rhizostoma.
- 3d Family. **Acotyla**: Lymnorea, Favonia, Geryonia; Berenice, Eudora, Carybdea.

The families of the Cyclomorpha are entirely artificial, and in no way express the natural affinities of the animals; and the families of the Poecilomorpha are borrowed from other writers,—the name of *Beroes*, proposed by Goldfuss, being changed to *Ciliata*, that of *Porpitæ* to *Papyracea*, and the name *Hydrostatica* retained from Cuvier. The Hydroids are referred partly to the class of Polyps, in the tribe Vaginiformia, and partly to his class Helianthoidea, which embraces Actinia, Zoanthus, and Lucernaria.

The animals belonging to the class of Acalephs are so peculiarly delicate, so difficult to handle, and so perishable, that the circumstances under which they may be studied, form almost as important an element in their investigation, as the aptitude of the observer to trace their history. But when the naturalist who devotes years to their study is not only an eminent physician, but at the same time a minute, accurate, and philosophical observer, pursuing his task under the most favorable circumstances, great results may be expected. This was the case of Eschscholtz, who, during two voyages around the world, applied himself chiefly to the investigation of these animals, and had better opportunities for studying their various types in their natural element than any other man had enjoyed before, not even excepting Péron and LeSueur. Aside from the large amount of information it contains, the "System der Acalephen" of Eschscholtz is a model work for the manner in which the subject is treated. Full, minute, explicit, decided, where he speaks from personal observation; unpretending, candid, and fair, where he alludes to the investigations of other distinguished authors; cautious and reserved where he has reasons to question the correctness of the statements of others,—he secured the admiration of his contemporaries and the gratitude of his followers, and those who have known him lament his early loss.

CLASSIFICATION OF ESCHSCHOLTZ, 1829.

The limits of the class of Acalephs, as circumscribed by Eschscholtz in 1829, coincide with those assigned to it by Cuvier from the beginning, with the only exception that the Actiniæ are excluded. The Hydroids are entirely ignored by Eschscholtz, as if they had no relations to the Acalephs. He divides, for the first time, this class into three natural orders, and distinguishes a number of natural families. All later classifications of the Acalephs are mere modifications or improvements of that of Eschscholtz.

1st Order. CTENOPHORÆ.

- 1st Family. Callianiridæ, with three genera: Cestum, Cydippe, Callianira.
- 2d Family. Mnemiidæ: Eucharis, Mnemia, Calymma, Axiotima.
- 3d Family. Beroidæ: Beroe, Medea, Pandora.

2d Order. DISCOPHORÆ.

First Division. *Discophoræ phanerocarpæ.*

- 1st Family. Rhizostomidæ: Cassiopea, Rhizostoma, Cephea.
- 2d Family. Medusidæ: Sthenonia, Medusa, Cyanea, Pelagia, Chrysaora, Ephyra.

Second Division. *Discophoræ cryptocarpæ.*

- 1st Family. Geryonidæ: Geryonia, Dianæa, Linuche, Saphenia, Eirene, Lymnorea, Favonia.
- 2d Family. Oceanidæ: Oceania, Callirhoe, Taumantias, Tima, Cytæis, Melicertum, Phorcynia.
- 3d Family. Æquoridæ: Æquorea, Mesonema, Ægina, Cunina, Eurybia, Polyxena.
- 4th Family. Berenicidæ: Eudora, Berenice.

3d Order. SIPHONOPHORÆ.

- 1st Family. Diphyidæ: Eudoxia, Ersæa, Aglaisma, Abyla, Diphyes, Cymba.
- 2d Family. Physophoridæ: Apolemia, Physophora, Hippopodius, Rhizophysa, Epibulia, Agalma, Athorybia, Stephanomia, Discolabe, Physalia.
- 3d Family. Velellidæ: Rataria, Velella, Porpita.

CLASSIFICATION OF DEBLAINVILLE, 1830–1834.

DeBlainville has introduced great modifications in the classification of the Acalephs, part of which he removed to the Mollusks. The following diagram gives a general idea of his views respecting the classification of the lower animals:—

ZOOPHYTES. 1. *False Zoophytes*, to be referred to the Mollusks: Physogrades and Diphyes, or perhaps to the Holothurians: Ciliobranches.
" " " " to the Articulates. Entozoa.
" " forming a heterogeneous assemblage of very small animals. Infusoria.
2. *Genuine Zoophytes.* Actinozoaria, containing 5 Classes: Cirrhodermaria, Arachnodermaria, Zoantharia, Polypiaria, and Zoophytaria.
Amophozoaria: Spongiæ.
3. *False Zoophytes*, to be referred to the vegetable kingdom: Corallinæ, Nematozoa, Psychodiaria.
" " neither animals nor plants. Zoösperms and Nullipores.

It appears from this sketch of DeBlainville's system, that he considers the Siphonophoræ of Eschscholtz as Mollusks, and the Ctenophoræ either as Mollusks or Echinoderms. The other Acalephs he calls ARACHNODERMARIA, and divides them in the following manner:—

1st Order. PULMOGRADA.
1st Section. *Simple Pulmogrades:* Eudora, Ephyra, Phorcynia, Eulimenes, Carybdea, Euryale.
2d Section. *Tentaculate Pulmogrades:* Berenice, Æquorea, Mesonema, Polyxena, Ægina, Cunina, Faveolia, Eurybia, Pegasia, Obelia.
3d Section. *Subproboscidate Pulmogrades:* Oceania, Aglaura, Melicerta, Cytæis, Thaumantias, Tima, Campanella.
4th Section. *Proboscidate Pulmogrades:* Orythia, Geryonia, Saphenia, Dianea, Linuche, Favonia, Lymnorea, Sthenonia.
5th Section. *Brachiate and pedunculate Pulmogrades:* Ocyroe, Cassiopea, Aurelia, Melitea, Evagora, Cephea, Rhizostoma, Chrysaora, Pelagia.
2d Order. CIRRHOGRADA. Velella, Rataria, Porpita.

The Hydroids are referred to the class of Polypiaria. An earlier diagram of these animals was published by DeBlainville in 1822, in his work "De l'Organisation des Animaux." See vol. 1 of this work, p. 198.

DeBlainville did not enjoy the same favorable opportunities for the study of the Acalephs as Eschscholtz; and yet he is the author of an original classification of these animals, which differs entirely from those of his predecessors. Eminent as a closet student, and deeply imbued with the conviction that Zoölogy required great reforms, and that methods may supply the deficiency of actual knowledge, he never hesitated in introducing great changes in the classification of the animal kingdom whenever a suggestion was presented to his mind, and without awaiting the opportunity for making the necessary investigations to test its accuracy and correctness. His views respecting some of the animals referred to the class of Acalephs, which he would remove from it, exemplify this disposition of his; and the many unnecessary changes which he made in the nomenclature of the lower animals are another evidence of that unhappy propensity. There are few examples of a more appropriate name for a new class in the animal kingdom, than that of Acalephæ, selected by Cuvier to designate, in general, all the animals allied to those known by the ancients under that name. It was at once adopted by all naturalists. The most important work ever published upon this class, as a whole, bears that name upon its very title; and yet DeBlainville does not hesitate to substitute for it a new, ill-sounding name, Arachnodermaria, the meaning of which, if it suggests any thing, recalls affinities with another type of animals, with which the Acalephs have no affinity.

CLASSIFICATION OF OKEN, 1835.

The views held by Oken upon classification and the affinities of animals have already been presented in my first volume (p. 212). It remains only to give a special account of his arrangement of the animals belonging to the type of Radiata. Oken does not unite the Echinoderms with the other radiated animals; but, founding upon the manner in which the parts of their solid envelope are movably united, and also upon the worm-like form of the Holothuriæ, unites them with the Articulates, in one and the same class with the Worms, as a distinct order of that class. The Acalephs are united, with the Polyps and Infusoria, into another primary division, the *Intestinal animals*, divided into three classes: the Infusoria, as Stomach-animals; the Polyps, as Intestine-animals; and the Acalephs, as Lacteal-animals. The class of Acalephs is itself subdivided into three orders:—

1st Order. The *Infusorial Acalephs*, or Siphonophoræ.
- 1st Tribe. Diphyes, Calpe, Abyla, Cymba, Aglaisma, Eudoxia.
- 2d Tribe. Rhizophysa, Stephanomia,—Physophora,—Physalia.
- 3d Tribe. Porpita, Lithactinia, Rataria, Velella.

2d Order. The *Polypoid Acalephs*, or Ctenophoræ.
- 1st Tribe. Eucharis, Cydippe,—Idya,—Medea, Pandora.
- 2d Tribe. Mnemia, Callianira, Cestum.
- 3d Tribe. Axiotima, Calymma, Alcinoe, Ocyrhoe.

3d Order. The *Acalephs proper*, or Discophoræ.
- 1st Tribe. Eudora, Berenice,—Geryonia,—Rhizostoma, Cassiopea, Cephea.
- 2d Tribe. Phorcynia, Melicertum, Thaumantias, Oceania, Callirhoe—Æquorea,—Ægina, Cunina, Polyxenia.
- 3d Tribe. Ephyra,—Aurelia,—Pelagia, Chrysaora, Cyanea.

This classification may be considered as a remodelling of Eschscholtz's, adapted to the views of the author respecting the manner in which the structure of the higher animals is represented by independent beings,—recalling, as it were, the different systems of their organs.

The history of the Acalephs has received very important accessions from the investigations of Mertens, who was naturalist in the Russian exploring expedition of the Seniavin. Unfortunately he died before having published his labors; and the only paper he left so far finished as to have appeared under his name is his "Beobachtungen und Untersuchungen über die Beroeartigen Akalephen," in 2d vol. 6e sér., Mém. Acad. Scien. Pétersbourg. Brandt, who had superintended the publication of this paper, afterwards worked up the materials left by Mertens relating to the other families of the Acalephs, and gave a full account of them in the "Ausführliche Beschreibung der von C. H. Mertens, auf seiner Weltumsegelung beobachteten Schirmquallen," 4e vol. Mém. Acad. Sc. Pétersbourg. The value of Mertens's contributions to the natural history of these animals may be inferred from the simple fact, that Brandt, without having seen the Acalephs he describes, could make elaborate descriptions of them merely from the drawings and scanty notes found among Mertens's papers. The fact is, the drawings of Mertens, and those of his travelling companion, Professor Postels, are among the most accurate and beautiful representations of Acalephs thus far published, and constitute by themselves an ample atlas of the whole order of Discophoræ.

CLASSIFICATION OF BRANDT, 1833.

Brandt, in his "Prodromus Descriptionis animalium ab H. Mertensio observatorum," published in the Memoirs of the Imperial Academy of Sciences of St. Petersburg, in 1833, has the following classification of the Acalephs, exclusive of the Beroids: —

DISCOPHORÆ. MEDUSIDÆ.

Monostomæ.

Oceanidæ: Circe, Conis.

Æquoridæ: Æquorea, Stomobrachiota, Mesonema, Zygodactyla, Æginopsis, Polyxenia.

Medusidæ: Phacellophora; Cyanea and Cyaneopsis; Aurelia: Monocraspedon, Diplocraspedon; Pelagia, Chrysaora.

Polystomæ.

Geryonidæ: Geryonia, Proboscidactyla, Hippocrene.

Rhizostomidæ: Cassiopea.

Incertæ sedis.

Berenicidæ: Staurophora.

SIPHONOPHORÆ.

Diphyidæ: Diphyes.

Physophoridæ: Physophora.

Rhizophysidæ: Epibulia: Macrosoma, Brachysoma.

Agalmidæ: Agalma.

Anthophysidæ: Athorybia, Anthophysa, Apolemiopsis.

Physalidæ: Physalia: Salacia, Alophota.

Velellidæ: *Velellinæ:* Velella, Aristerodexia; *Porpitinæ:* Porpita.

Lesson is one of the naturalists who had the best opportunities for observing the Acalephs. Embarked with Garnot on board the Coquille, he made the voyage around the world with Captain Duperrey, and prepared many beautiful illustrations of Acalephs for the zoological atlas of that expedition. On his return he made the most extensive collection of drawings of these animals ever brought together, with the intention of publishing a complete Iconography of this class; but the magnitude of the undertaking prevented its execution, and nothing was published but a "Prodrome d'une Monographie des Méduses," with a short notice of two hundred and thirty-seven species, arranged in seventy genera. Some of the plates were afterwards introduced in the "Centurie Zoologique," and the text appeared, in 1843, among the "Suites à Buffon," under the title of "Histoire naturelle des Zoophytes, Acalèphes." To this day, this is the chief work of reference for the study of the Acalephs; but it is much to be regretted that it is neither methodical in its plan nor critical in its details. It is rather a compilation than an original work; and yet it contains much that cannot be found elsewhere. Edw. Forbes has the following just but severe criticism of this extraordinary production: "This work is one of the most useful, and yet one of the most provoking, in its department of Natural History: useful, because it brings together, *verbatim*, every thing that has been written upon the Medusæ in France; provoking, because every attempt in it at an arrangement or digest of the matter so collected serves only to make the obscure more obscure and the crude more crude. It is executed without any judgment, though with considerable industry. Of what has been done outside of France it is a most imperfect account."[1]

CLASSIFICATION OF LESSON, 1843.

Like his predecessors, Lesson does not allude to the Hydroids in connection with the Acalephs.

1st Family. BEROIDEÆ.
- 1st Division. *Ciliobranches* or *Iriptères*.
  - 1st Tribe. Cestoideæ: Cestum, Lemniscus.
  - 2d Tribe. Callianiræ: Callianira, Chiaia, Polyptera, Mnemia, Bucephalon, Bolina.
  - 3d Tribe. Leucothoeæ: Leucothoea.
  - 4th Tribe. Calymmeæ: Calymma, Eucharis, Alcinoe, LeSueuria, Axiotima.
  - 5th Tribe. Neisidæ: Neis.
  - 6th Tribe. Ocyroeæ: Ocyroe.
  - 7th Tribe. Cydippæ: Mertensia, Anais, Eschscholtzia, Janira, Cydippe.
  - 8th Tribe. Beroæ: Beroe, Idya, Medea, Cydalisia, Pandora.
- 2d Division. *Acils*.
  - False Beroids: Galeolaria, Doliolum, Rosacea, Sulculeolaria, Praia, Noctiluca, Appendicularia.

[1] EDW. FORBES. A monograph of the British Naked-eyed Medusæ, London, 1848, p. 98.

2d Family. MEDUSÆ.

1st Group. *Medusæ without proboscis.*

1st Tribe. Eudoræ: Discus, Eudora, Eulimenes, Phorcynia, Pileola, Epomis, Ephyra.

2d Tribe. Carybdeæ: Carybdea, Obelia.

3d Tribe. Marsupialæ: Marsupialis, Bursarius, Mitra, Eurybia, Cytæis, Campanella, Scyphis.

4th Tribe. Nucleiferæ: Turris, Circe, Conis, Tiara, Tholus, Pandea, Bougainvillia, Proboscidactyla, Melicertum, Aglaura, Laodicea, Microstoma.

5th Tribe. Berenicidæ: Berenix, Staurophora.

2d Group. *Oceanides*, or genuine Medusæ with a round mouth but no proboscis.

1st Tribe. Thalassanthæ: Pegasia, Faveolia, Cunina, Ægina, Æginopsis.

2d Tribe. Æquoridæ: Æquorea, Polyxenia.

3d Tribe. Oceanidæ: Stomobrachiota, Mesonema, Oceania, Patera.

3d Group. *Agaricine Medusæ*, or Medusæ with proboscis: Melicerta, Saphenia, Dianea, Orythia, Geryonia, Liriope, Xanthea, Sarsia, Tima, Thaumantias, Linuche, Usous, Lymnorea, Favonia.

4th Group. *Rhizostomeæ*, or Medusæ with a central peduncle.

1st Tribe. Medusidæ, or Medusæ monostomeæ.

1st Section. Without tentacles around the disc: Biblis, Melitea, Evagora, Salamis, Phacellophora.

2d Section. With tentacles around the disc: Callirhoe, Sthenonia, Aurelia, Claustra, Cyanea, Cyaneopsis, Pelagia, Chrysaora.

2d Tribe. Rhizostomidæ, or Medusæ Polystomeæ: Ocyroe, Cassiopea, Cephea, Rhizostoma.

3d Family. DIPHYIDÆ.

1st Tribe. Polygastricæ: Diphyes, Heterodiphyes; Calpe, Abyla.

2d Tribe. Monogastricæ: Microdiphyes, Cymba, Enneagonum, Cuboides, Cucubalus, Cucullus, Eudoxia, Amphiroa, Ersæa, Aglaisma.

4th Family. POLYTOMÆ, or PLETHOSOMÆ.

1st Tribe. Plethosomæ: Plethosoma, Polytomus, Hippopodius, Elephantopes, Racemis.

2d Tribe. Stephanomiæ: Stephanomia, Sarcoconus, Strobila.

5th Family. PHYSOPHORÆ.

1st Tribe. Rhizophysæ: Rhizophysa, Brachysoma.

2d Tribe. Discolabæ: Discolabe, Diphysa.

3d Tribe. Angelæ: Angela.

4th Tribe. Athorybiæ: Athorybia, Anthophysa.

5th Tribe. Physophoræ: Physophora.

6th Tribe. Agalmæ: Agalma.

7th Tribe. Apolemiæ: Apolemia, Apolemiopsis.

6th Family. PHYSALIÆ: Physalia.

7th Family. VELELLÆ: Velella, Rataria.

8th Family. PORPITÆ: Porpita, Ratis, Acies.

A sketch of this classification was already published in 1835 (Proceed. Zool. Soc. London, 1835, Part III. p. 2), and a special paper upon the Beroids, in Ann. Sc. Nat. 2de sér. 1837, vol. 5. The above diagram gives the classification of Lesson, as it appears in his last work, in the Suites à Buffon.

There is hardly a branch of Natural History to which Edw. Forbes has not made some valuable contribution. His investigations upon the distribution of marine animals, as bearing upon the geological changes which have affected their area, have left a permanent impression upon the progress of modern Geology. Among his special zoological studies, the natural history of the Acalephs formed always a favorite topic, to which he constantly returned with renewed interest. His monograph of the British naked-eyed Medusæ contains a summary of what he had done in that direction up to the year 1848. In the preface to this work he pays a just tribute of gratitude to his friend Mr. McAndrew, to whom he was mainly indebted for the facilities he enjoyed in collecting these materials, and whose name will forever remain associated with that of Edw. Forbes in the memory of naturalists.

CLASSIFICATION OF EDW. FORBES, 1848.

Forbes's classification, published in his "Monograph of the British Naked-eyed Medusæ," relates only to the Discophoræ, which he divides into two natural groups, corresponding to the Discophoræ phanerocarpæ and cryptocarpæ of Eschscholtz, but based upon different characters, not before taken into consideration in the arrangement of the Acalephs. They are as follows: —

I. Gymnophthalmata.
- 1st Family. Willsiadæ: Wilsia.
- 2d Family. Oceanidæ: Turris, Saphenia, Oceania.
- 3d Family. Æquoreadæ: Stomobrachium, Polyxenia.
- 4th Family. Circeadæ: Circe.
- 5th Family. Geryoniadæ: Geryonia, Tima, Geryonopsis, Thaumantias, Slabberia.
- 6th Family. Sarsiadæ: Sarsia, Bougainvillea, Lizzia, Modeeria, Euphysa, Steenstruppia.

II. Steganophthalmata. Aurelia, Pelagia, Chrysaora, Rhizostoma, Cassiopea, Cyanæa.

MY OWN VIEWS OF THE CLASSIFICATION OF ACALEPHS.

In a series of lectures, delivered before the Lowell Institute in the winter of 1848–1849, a phonographic report of which appeared first in the "Traveller" and afterwards in the form of a separate pamphlet, I have presented my views of the natural affinities of the Radiates in general, and there began to trace the homologies of these animals with the other Radiates, and introduced some changes in their classification, which an uninterrupted study for more than ten years longer, along the whole Atlantic coast of North America, from Canada to Texas, has only confirmed and enlarged by furnishing additional means of comparisons.

There I circumscribed the type of Radiata in the same manner in which I now think it should be circumscribed, admitting in it three classes only, — the Polyps, the Acalephs, and the Echinoderms. There I showed also that the Hydroids are genuine Acalephs, and should be united, not only with the naked-eyed Medusæ, but also with the Siphonophoræ. There also I traced the special homologies of the Ctenophoræ and other Acalephs, and the general homologies of all Radiata, including the Echinoderms. There I advocated the compound character of the Siphonophoræ, and carried that view even further than it is carried by some naturalists, showing, what I believe to be true, that certain parts of their communities, which are still considered by some anatomists as organs, are in reality distinct individuals.

I do not make this somewhat extended reference to my "Lectures," in order to substantiate special claims of priority, but solely to prevent any imputation of having borrowed from others the views I have derived from my own investigations, and upon which I may have to dwell more fully in the course of this work. This appears to me the more necessary, since the reports of my lectures have had only a very limited circulation in Europe.

We are indebted to Lütken for valuable contributions to the natural history of the Acalephs of Greenland and Scandinavia, in connection with which he has published a new systematic arrangement of the naked-eyed Medusæ. As I know this paper only from the abstracts given by Leuckart in the Archiv für Naturgeschichte for 1854, 2d vol., p. 424, I abstain from further remarks about it.

LÜTKEN'S CLASSIFICATION OF THE NAKED-EYED MEDUSÆ, 1850.

1st Group.	1st Family.	Æginea: Carybdea, Eurybia, Cunina, Ægina, Æginopsis, Polyxenia.
2d Group.	1st Family.	Æquoreadæ: Æquorea, Mesonema, Stomobrachium, Thaumantias.
	2d Family.	Oceanidæ: Oceania, Saphenia, Turris, Modeeria.
	3d Family.	Bougainvilleæ: Bougainvillea, Lizzia, Rathkia.
	4th Family.	Geryonidæ: Geryonia, Tima, Geryonopsis, Dianæa, Circe.
	5th Family.	Sarsiadæ: Sarsia, Slabberia, Steenstruppia, Euphysa.
3d Group.	1st Family.	Willsiadæ: Willsia, Proboscidactyla, Berenice.

Milne-Edwards never attempted systematically to present his views of the affinities of the Acalephs in the form of a special classification, though we owe to him important contributions to the history of this class. Von Siebold, in his text-book of comparative anatomy, has adopted the classification of Eschscholtz, which, to this day, is followed by most naturalists.

Since, judging from my observations upon Millepora, a large number of Corals must be considered as belonging to the type of Hydroids, it is necessary to introduce here the classification of Corals by Milne-Edwards, in order more directly to show what changes are likely to be rendered necessary in the systematic arrangement of the Corals, in consequence of my discovery of the acalephian affinities of the genus Millepora.

When the two highest authorities in the natural history of Corals, Milne-Edwards and Dana, agree in considering the genus Millepora as a member of the class of Polyps, I would not venture to suggest a different view of its affinities, had I not been able leisurely to examine the animal of that kind of Coral, which had never been observed before, and satisfied myself that it has none of the typical characteristics of the Polyps, neither radiating partitions, nor digestive sac hanging in the main cavity, while it agrees so closely with the true Hydroids, and especially with the genus Hydractinia, that there can be no doubt left in what direction its natural affinities point. (Compare Pl. XV. *Figs.* 3–13 with Pl. XVI., respecting which more will be found in the sequel.) With these facts before us, Millepora must unquestionably be removed from the class of Polyps and referred to that of the Acalephs, as soon as it is conceded that the Hydroids are Acalephs, and not Polyps.

RELATIONS ASSIGNED BY MILNE-EDWARDS TO THE TABULATA AND RUGOSA, AND TO SOME OF THE HYDROIDS IN THE CLASS OF POLYPI, 1850–1852.

1st Sub-class. CORALLARIA.

1st Order. *Zoantharia.*

1st Group. Malacodermata. Families: Actinidæ; Actininæ, Thalassianthinæ, Phyllactinæ, Zoanthinæ; Cerianthidæ; Minyadidæ.

2d Group. Aporosa. Families: Turbinolidæ; Cyathininæ, Turbinolinæ; Pseudotur binolidæ; Oculinidæ; Pseudoculinidæ; Astræidæ; Eusmilinæ, Astræinæ; Pseudastreidæ; Fungidæ; Funginæ, Lophoserinæ.

3d Group. Perforata. Families: Madreporidæ, Euspammidæ, Madreporinæ, Turbinariæ; Poritidæ; Poritinæ, Alveoporinæ.

4th Group. Tabulata. Families: Milleporidæ; Favositidæ: Favositinæ, Chætitinæ, Halysitinæ, Pocilloporinæ: Seriatoporidæ; Thecidæ.

5th Group. Tubulosa. Family: Auloporidæ.

6th Group. Rugosa. Families: Stauridæ; Cyathaxonidæ; Cyathophyllidæ: Zaphrentinæ, Cyathophyllidæ, Axophyllinæ.

2d Order. *Alcyonaria.* Families: Alcyonidæ; Cornularinæ, Telesthinæ, Alcyoninæ, Tubiporinæ; Gorgonidæ; Gorgoninæ, Isidinæ, Coralliinæ; Pennatulidæ.

3d Order. *Podactinaria.* Family: Lucernaridæ.

2d Sub-class. HYDRARIA. Family: Hydridæ.

Of these groups I hold that the *Zoantharia*, Malacodermata, Aporosa and Perforata, and the *Alcyonaria* alone, are genuine Polyps; and that the Tabulata, Tubulosa, Rugosa, Podactinaria, and Hydraria are Acalephs.

Since, from this time forward, the influence of Embryology upon the classifications of Acalephs is more or less distinctly felt, I deem it necessary to introduce here some comparisons between the earlier attempts at a systematic arrangement of these animals and the later systems, in order to render more evident the progress made thus far.

The classification of Lamarck, and the names he gave to the primary subdivisions of the Acalephs, truly express the condition of our science at that period. The natural limits of the class had not yet been found, — nay, the Acalephs were not yet separated from the Echinoderms, as a class, but Medusæ had been observed, a considerable number of them were superficially known, and, next to them, many animals had been noticed, bearing evidently some relation or other to the Medusæ; but what these relations were, was not understood; and so all these species were united into one group by the side of the regular Medusæ, under the name of Anomalous Radiates.

Péron and LeSueur next investigated these groups singly, — LeSueur devoting his attention chiefly to the compound ones, which he at this early period already separated from the compound Tunicata, while, together with Péron, he illustrated the Discophoræ generally.

Cuvier's merits consist mainly in the separation of the Acalephs as a class; but the limits he assigned to it were not altogether true to nature. Schweigger only copied Lamarck and Cuvier as far as classification is concerned.

To Goldfuss, science is indebted for the first discriminating subdivision of the Acalephs. For the first time the Ctenophoræ were brought together by him and separated from the Siphonophoræ, and these again divided into two families, while all Discophoræ remained together. Chamisso and Eysenhardt copied Goldfuss, while, still later, Latreille fell back upon the first outlines of Lamarck.

Eschscholtz, next to Cuvier, may be considered as the founder of the classification of Acalephs, for while Cuvier distinguished the class, Eschscholtz first divided it into three natural orders, one of which he very properly subdivided into two divisions, already pointing in the direction of future progress; for hereafter the Discophoræ cryptocarpæ will appear more clearly allied to the Siphonophoræ than they are to the Discophoræ phanerocarpæ. His subdivision of the orders into natural families was a still greater improvement. DeBlainville did not mark a progress in the study of this class: his suggestions were mere guesses, mostly far out of the right course. Oken simply copied Eschscholtz. Brandt added a few families among the Siphonophoræ, the number of which was still further increased, often without much discrimination or criticism, by Lesson. Forbes, and Lütken also, described some new families; but Forbes made an important addition to the classification of Eschscholtz, by pointing out further differences between the two divisions of the Discophoræ, which he called Steganophthalmata and Gymnophthalmata.

With Sars and Steenstrup a new epoch begins for the history of the Acalephs, though neither of them has attempted to classify these animals; but it is to their investigations that science is indebted for the first facts bearing upon the affinities of the Hydroids to the Discophoræ cryptocarpæ, or the Gymnophthalmata of

Forbes. These affinities I have recognized in uniting the Hydroids and Gymnophthalmata with the Siphonophoræ in one order, to which I have lately added the Tabulata and Rugosa of Milne-Edwards. This step seems to me to have at last circumscribed the class within its natural limits, and fixed its boundaries on the side of the Polyps, where the dividing line had remained more vague than in any other direction.

I have already presented my objections to some points of the classification of Vogt relating to the Acalephs in general. I have only to give here an outline of the minor divisions which he admits among these animals. But while I cannot agree with his classification, it is but justice to him to say that his paper upon the Siphonophoræ of Nizza is one of the most valuable contributions of modern times to the natural history of these animals, forming, in connection with similar papers by Leuckart, Kölliker, Gegenbaur, and Huxley, a very full description of all the representatives of this type.

CLASSIFICATION OF VOGT, 1851.

Referring the Ctenophoræ to the Mollusks, Vogt, in his "Zoologische Briefe," published in 1851, has adopted the following classification for the Acalephs, after dividing the Radiata into four classes: *Polyps*, including Lucernaria but not the other Hydroids, *Hydromedusæ*, *Siphonophoræ*, and *Echinoderms*.

The class of HYDROMEDUSÆ (Quallenpolypen) is divided into two orders:—

1st Order. *Hydroids*, with three families: Hydrida, Tubularida, Campanularida.

2d Order. *Medusæ*, with six families: Medusida, Oceanida, Æquorida, Berenicida, Rhizostomida, Geryonida.

The class of SIPHONOPHORÆ (Röhrenquallen) is divided into three families: Physalida, Velellida, and Diphyida, to which Stephanomia is appended.

The class of CTENOPHORÆ (Rippenquallen) is divided into two families: Beroida and Callianirida.

In his paper upon the Siphonophoræ of Nizza, published in 1854, Vogt has appended the following classification of the order of his Hydromedusæ, which embraces them:—

Order I. POLYPI NECHALEI.

1st Division. With active natatory organs. Polyps provided with fishing threads. Swimming belly hollow.

1st Family. *Agalmides:* Apolemia, Agalma, Physophora.—The genera Rhizophysa, Brachysoma, Stephanomia, Epibulia, Sarcoconus, and Discolabe, are considered as founded upon mutilated animals.

2d Family. *Hippopodides:* Hippopodius, Vogtia.—Elephantopes and Racemis are questionable.

3d Family. *Diphyides:* Praya, Galeolaria, Diphyes. All the other genera referred to this family are rejected.

4th Family. *Athorybides:* Athorybia.—The genus Anthophysa is questioned.

2d Division. With passive natatory organs.

1st Family. *Physalides:* Physalia.—The sub-genera Salacias, Cystisoma, and Alophotes, are considered as useless; and Angela as probably near Physalia.

2d Family. *Velellides:* Velella and Porpita.—Rataria is young Velella.

The contributions of Kölliker to the natural history of the Acalephs are as varied as they are important, though sometimes consisting simply of short notices. A report of the investigations made by him in Messina, in connection with Gegenbaur and H. Müller, and published in the "Zeitschrift fur wissenschaftliche Zoologie," vol. 4, p. 299, contains a vast amount of information upon the Acalephs of the Mediterranean. In his larger work on Siphonophoræ, "Die Schwimmpolypen von Messina," however, he has not only given a very full account of the species he observed in Messina, including new genera and the characteristics of new families, but he has also published a diagram of his views respecting the affinities of the lower animals generally, as follows:—

CLASSIFICATION OF KÖLLIKER, 1853.

The members of the class of Acalephs are so combined with the Polyps and Bryozoa by Kölliker, that his views respecting their affinities can only be appreciated by a comparative study of his whole diagram of the Radiates with other classifications of the Invertebrates generally. He divides the Radiata in the following manner:—

I. RADIATA MOLLUSCOIDEA.

1st Group. HYDROIDEA. A. *Hydroidea sessilia:* Hydra.
B. *Hydroidea nechalea:* Physophora, Diphyes, Athorybia, etc.

2d Group. HYDROMEDUSIDA: Coryne, Sertularia, Tubularia, Velella, and Gymnopthalmata: Oceania, Bougainvillea, etc.

3d Group. DISCOPHORA: Steganophthalmata: Medusa, Rhizostoma, Cephea.

4th Group. CTENOPHORA.

5th Group. ANTHOZOA.

6th Group. BRYOZOA.

II. RADIATA ECHINODERMATA.

1st Group. HOLOTHURIDA.—2d Group. ECHINIDA.—3d Group. ASTERIDA.—4th Group. CRINOIDEA.

Kölliker thus coincides with Leuckart in separating the Echinoderms from the Polyps and Acalephs as a primary group of the animal kingdom, and uniting the minor sections of the two latter classes into another great division. Disregarding, however, all the categories of the system of Zoölogy by which animals may be divided into classes and orders, he divides the Hydroidea nechalea, which he calls also POLYPI NECHALEI, into five families:—

1st Family. Physophoridæ: Forskalia, Agalmopsis, Apolemia,—Physophora,—Athorybia.
2d Family. Hippopodiidæ: Hippopodius, Vogtia.
3d Family. Prayidæ: Praya.
4th Family. Diphyidæ: Diphyes, Abyla.
5th Family. Velellidæ: Velella, Porpita.

Though Leuckart has not published a general classification of the Acalephs, he has done so much for the advancement of the natural history of that class of animals, and for a more correct appreciation of the affinities of the lower animals generally, that he deserves a prominent place in a history of their classification. (Compare vol. 1, pp. 179 and 209.) His special contributions to the systematic arrangement of the Acalephs relate chiefly to the Siphonophoræ, and are expressed in the following diagram: —

LEUCKART'S CLASSIFICATION OF THE SIPHONOPHORÆ, 1854.

1st Family. Calycophoridæ.
 1st Sub-family. *Diphyidæ:* Abyla, Diphyes, Galeolaria, — Praya.
 2d Sub-family. *Hippopodiidæ:* Hippopodius.
2d Family. Physophoridæ.
 1st Sub-family. *Stephanomidæ:* Apolemia, Agalma, Forskalia.
 2d Sub-family. *Physophoridæ* proper: Physophora.
3d Family. Rhizophysidæ: Rhizophysa.
4th Family. Physalidæ: Physalia.
5th Family. Velellidæ: Velella, Porpita.

In the additions to the German edition of Van der Hoeven's Handbook of Zoology, Leuckart has divided the Ctenophoræ into two orders, the *Eurystomata* and *Stenostomata*, — an arrangement already hinted at by Eschscholtz and Van der Hoeven.

Since Eschscholtz, no naturalist has made more extensive and more valuable contributions to the natural history and anatomy of the Acalephs in general, than Gegenbaur, who has extended his researches to all the orders of the class, including the study of their development, in his comprehensive investigations. His classifications of the different groups of the class contain much also that is new and important, though I think he is mistaken in the rank he assigns to some of them. The different works in which he has published his researches are enumerated above (p. 27, note 13, and p. 87, note 1.) The chief importance of Gegenbaur's contributions to the classification of the Acalephs consists in the discrimination of several new families among the naked-eyed Medusæ, and more especially in the introduction of a new consideration by which to distinguish the Discophoræ proper from the naked-eyed Medusæ. It has been seen above, that Eschscholtz admitted two divisions among the Discophoræ, one of which he called Discophoræ phanerocarpæ, and the other Discophoræ cryptocarpæ, founding this distinction upon the presence or absence of special pouches for the reception of the sexual apparatus. Forbes admitted also two divisions, calling one Steganophthalmata, because the eyespecks are enclosed in a scalloped fold of the margin of the disk, and the other Gymnophthalmata, because the eyespecks are exposed along the margin, in close connection with the tentacles and the circular tubes. Gegenbaur founded a similar subdivision upon the presence or absence of an inverted rim along that same margin.

CLASSIFICATION OF GEGENBAUR, 1856–1859.

Gegenbaur is the last author to whose systematic views I have to allude, as far as they relate to the Acalephs in general: later authors have only considered parts of the subject. He, like most recent German writers, adopts the primary division of the Radiata into Cœlenterata and Echinodermata, proposed by Leuckart, and in his Textbook of Comparative Anatomy subdivides the Cœlenterata into three classes: Polypi, Hydromedusida, and Ctenophora. Here the Hydroids are all referred to the class of the Hydromedusida, with the sole exception of Lucernaria, which is left among the Polyps. The Hydromedusida themselves are divided in the following manner:—

1st Order. Hydroidea: Coryne, Syncoryne, Hydractinia, Sertularia, Pennaria;—Campanularia, Eudendrium, Tubularia.

2d Order. Medusida: 1° *Craspedota*: Oceania, Sarsia, Lizzia;—Geryonia;—Æquorea;—Ægineta, Cunina. 2° *Acraspeda*: Pelagia, Aurelia, Chrysaora;—Rhizostoma, Cassiopeia.

3d Order. Siphonophora: Velella, Porpita;—Diphyes, Abyla;—Agalma, Physophora, Physalia.

To the class Ctenophora the genera Cestum, Cydippe;—Mnemia, LeSueuria;—Eucharis;—and Beroe, are referred. But Gegenbaur had already published a more special account of his view of the Ctenophora in 1856, in the "Archiv für Naturgeschichte," p. 163, in which he adopts the following families:—

Callianiridæ: Callianira.

Calymnidæ: Calymna, Mnemia, Axiotima, Bolina, Eucharis, Leucothoe, Alcinoe, Chiaja, LeSueuria, and Euramphæa.

Cestidæ: Cestum.

Cydippidæ: Neis, Ocyroe, Mertensia *Less.*, Anais, Eschscholtzia, Mertensia *Gegenb.*, Janira, Cydippe, Pleurobrachia, Beroe *Mert.*, Owenia.

Beroidæ: Beroe (Idya, Cydalisa, Medea).—Sicyosoma.

In 1857, Gegenbaur published a special paper upon the Discophoræ in the Zeitschrift für wissenschaftliche Zoölogie, in which he admits two great divisions, corresponding to the *Phanerocarpæ* and *Cryptocarpæ* of Eschscholtz, and to the *Steganophthalmata* and *Gymnophthalmata* of Forbes, as follows:—

Acraspeda, with four families:—

- Rhizostomidæ: Rhizostoma, Cephea, and Cassiopeia.
- Medusidæ: Aurelia, Sthenonia, and Cyanea.
- Pelagidæ: Chrysaora, Pelagia, and Nausithoe (Octogonia).
- Charybdeidæ: Charybdea.

Craspedota, with seven families:—

- Oceanidæ: Oceania, Saphenia, Turris, Sarsia, Modeeria, Bougainvillea, Lizzia, Cytæis, Zanclea, Steenstruppia, Euphysa, Cladonema, Willsia, Chrysomitra; with five sub-families, *Oceanidæ* proper, *Sarsiadæ*, *Bougainvillidæ*, *Willsiadæ*, and *Cladonemidæ*.
- Thaumantidæ: Thaumantias, Staurophora, Tiaropsis, and Tima.
- Æquoridæ: Æquorea, Mesonema, Stomobrachium.
- Eucopidæ: Eucope, Sminthea, Eurybiopsis, Aglaura.
- Trachynemidæ: Trachynema, Rhopalonema.
- Geryonidæ: Geryonia, Liriope.
- Æginidæ: Cunina, Ægineta, Ægina, Æginopsis, Polyxenia.

The paper of J. McCrady upon the Gymnophthalmata of Charleston harbor, published in the Proceedings of the Elliott Society of Natural History in 1858, contains much interesting, and some highly important and novel, information upon the naked-eyed Medusæ of South Carolina, to which I shall have frequent opportunities of referring hereafter. For the present, I shall only allude to the classification he has proposed of the lowest order of the Acalephs. He is the first naturalist who has adopted the order of Hydroids with the limits I have assigned to it; but he has introduced a new arrangement of the minor groups.

CLASSIFICATION OF THE HYDROIDS BY J. McCRADY, 1858.

1st Sub-order. ENDOSTOMATA.

1st Family. *Corynidæ.* Oceanidæ: Oceania, Turritopsis, Turris, Modeeria, Saphenia.
Sarsiadæ: Sarsia, Corynitis, Dipurena, Slabberia.
Clavidæ: Clava.

2d Family. *Velellidæ.* Velella, Porpita, Chrysomitra, Rataria.

3d Family. *Tubularidæ.*
Pennaridæ: Cladonema, Zanclea, Pennaria, Willsia.
Tubularidæ: Steenstruppia, Euphysa, Tubularia, Corymorpha.
Hippocrenidæ: Nemopsis, Lizzia, Bougainvillea, Hippocrene, Cytæis, Eudendrium, Hydractinia.

4th Family. *Siphonophoræ.*
Physophoridæ: Forskalia, Agalma, Agalmopsis, Physophora, etc.
Hippopodidæ: Hippopodius, Vogtia.
Diphyidæ: Prayia, Diphyes, Eudoxia, etc.
Physalidæ: Physalia.

2d Sub-order. EXOSTOMATA.

1st Family. *Campanularidæ.*
Thaumantiadæ: Thaumantias, Staurophora, Tiaropsis.
Eucopidæ: Geryonopsis, Tima, Eucope, Eucheilota, Epenthesis, Campanularia.

2d Family. *Sertularidæ.* Sertularia, Halecium, Thuiaria, Plumularia, Aglaophenia, Antennularia.

3d Family.
Circeadæ. Circe, Persa, Aglaura.
Trachynemidæ. Trachynema, Rhopalonema.
Stomobrachidæ. Stomobrachium, Mesonema.
Geryonidæ. Geryonia, Liriope.
Æquoriadæ. Æquorea, Rhacostoma.

4th Family. *Æginidæ.* Cunina, Ægina, Ægineta, Æginopsis, Polyxenia.

Besides extensive and valuable contributions upon the structure and affinities of the Acalephs in general, published in the Transactions of the Royal Society of London, and of the Siphonophoræ in particular, published in Müller's Archiv, Huxley has lately proposed a new classification of the latter, which he calls Hydrozoa.

HUXLEY'S CLASSIFICATION OF THE SIPHONOPHORÆ, 1859.

HYDROZOA.

I. CALYCOPHORIDÆ.

- 1st Family. Diphydæ: Diphyes, Galeolaria, Abyla.
- 2d Family. Sphæronectidæ: Sphæronectes.
- 3d Family. Prayidæ: Praya.
- 4th Family. Hippopodiidæ: Hippopodius, Vogtia.

II. PHYSOPHORIDÆ.

- 1st Family. Apolemiadæ: Apolemia.
- 2d Family. Stephanomiadæ: Halistemma, Forskalia, Stephanomia, Agalma.
- 3d Family. Physophoriadæ: Physophora.
- 4th Family. Athorybiadæ: Athorybia.
- 5th Family. Rhizophysiadæ: Rhizophysa.
- 6th Family. Physalidæ: Physalia.
- 7th Family. Velellidæ: Velella, Porpita.

From the circumstance that his last work embraces all the animals then referred to the class, Lesson truly marks the close of a period in the history of the progress of the classification of Acalephs. From his days forward, the improvements bear chiefly upon the arrangement of the Hydroids, first brought into the sphere of attraction of the Medusæ about that time. Affinities, unsuspected before, lead to new combinations; and a more intimate acquaintance with the structure of all these animals, by the very novelty of the disclosures, suggests comparisons with the remotest types, and mere analogies are exalted into real affinities. But step by step, the test of homological relationship being applied to these aberrations, and embryological study adding its controlling influence, the Acalephs are finally circumscribed within limits which would now seem natural, and subdivided into groups which are not likely to undergo other than changes of secondary importance.

In concluding this rapid sketch of the classifications of the Acalephs I may be permitted to remark, that a retrospective glance over the many attempts thus far made to express the various degrees and different kinds of affinities of these animals, in the shape of diagrams, should satisfy any one how readily different authors, approaching the study of these animals with a very different preparation, have in the end agreed upon the natural limits of a larger and larger number of their subordinate groups, in proportion as the information concerning these groups has become more and more precise. The disagreement among authors has been most persistent upon the classification of those animals only, respecting the structure of which our knowledge has also remained deficient for a longer period; and it is cheering to see how, with increasing knowledge, the most extreme views have been gradually converging in the same direction. This condition of things excites a strong hope, that, ultimately, all differences among naturalists respecting classification may be settled; when the conformity of views will itself become an additional evidence that the system exists in nature, and not in the minds of those who have contributed to decipher it.

PART II.

CTENOPHORÆ.

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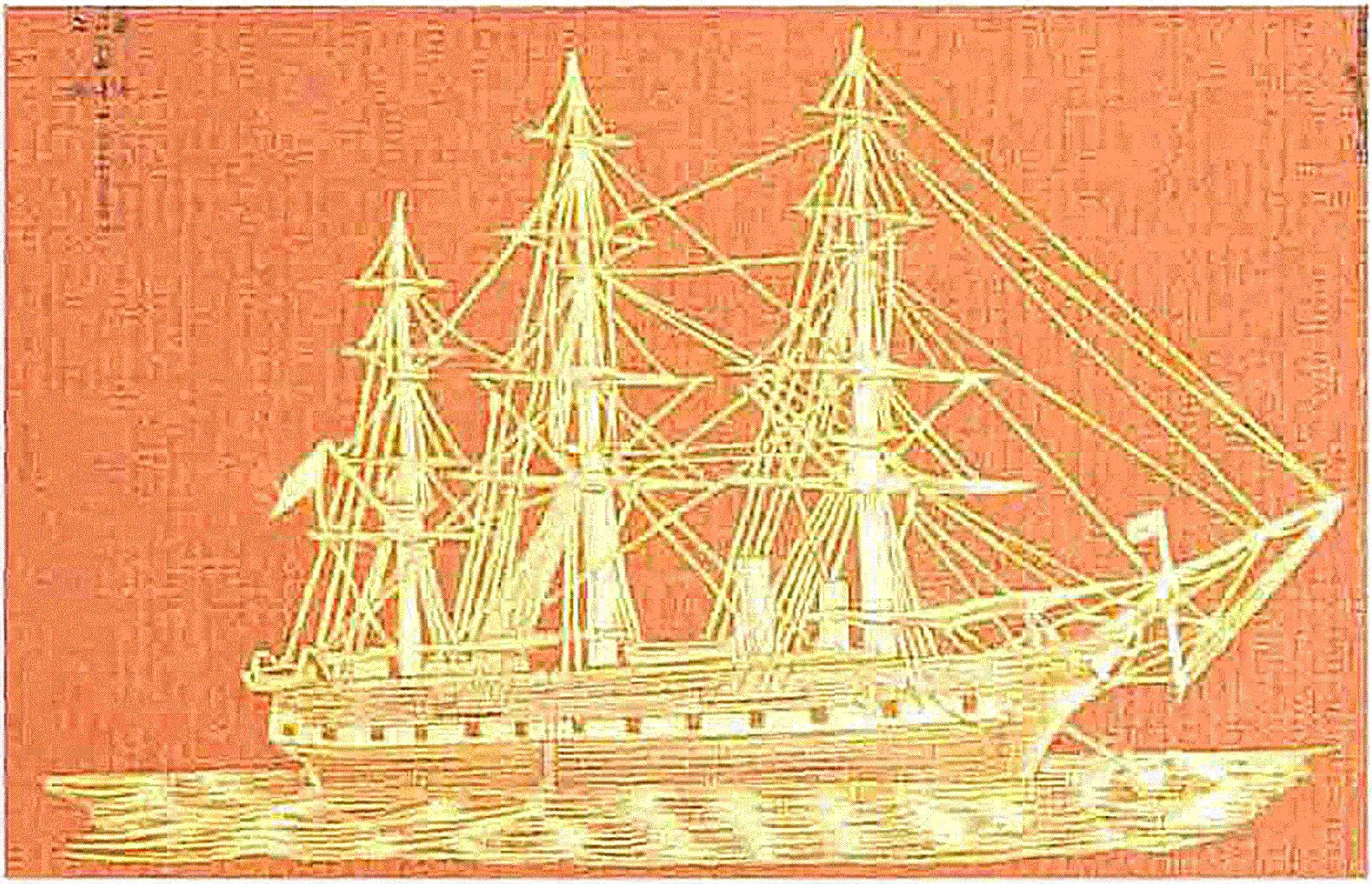


H.M.S. CHALLENGER

CTENOPHORÆ.

CHAPTER FIRST.

CTENOPHORÆ IN GENERAL.

SECTION I.

STRUCTURAL FEATURES OF THE CTENOPHORÆ IN GENERAL.

I NEED not repeat here what I have stated in the first part of this volume respecting the affinities of the Ctenophoræ. They are unquestionably Radiates belonging to the class of Acalephs, in which they form a natural order. This being admitted, it remains now for me to present a sketch of their structural peculiarities, in conformity with their general and special homologies, and an outline of their mode of life founded upon a knowledge of their special structure.[1]

[1] We are indebted to Gegenbaur for the latest and most comprehensive summary of what is now known about Ctenophoræ. It is therefore proper, that whatever critical remarks I may have to present upon the views entertained by other naturalists, respecting this group of animals, should be made with special reference to his paper, "Studien über Organisation und Systematik der Ctenophoren," in "Archiv für Naturgeschichte, 1856," 1 vol. p. 163. Gegenbaur, with Leuckart, considers them as constituting one harmonious primary group with the Medusæ, Hydroids, and Anthozoa, called Cœlenterata by the latter. I have already presented my objections to the separation of the Cœlenterata and Echinodermata as two distinct primary divisions of the animal kingdom, upon the broad ground that these divisions do not differ in *the plan of their structure*, but simply in *the mode of execution of that plan* (pp. 64–72); and it only remains for me to show that the structure of all these animals is strictly homological, and to remind those naturalists who may feel inclined to regard the distinction between a plan of structure and its mode of execution as of secondary importance, or as an inno-

The Ctenophoræ are free Acalephs moving in various ways, their main axis being generally turned in the direction of their onward motion, but at times also

vation of mine, that K. E. von Baer long ago already insisted upon the necessity of the distinction, in view of an accurate appreciation of the true relations of animals, though his warning has not been heeded. (Comp. vol. 1, p. 221.) The reason why Baer's suggestion to distinguish between *the degree of perfection in the structure of animals* and the *type of organization* has not been followed out, lies perhaps in the vagueness of the expressions he uses: but whosoever has comprehended that distinction for himself cannot fail to perceive that what I have alluded to when discussing the value and significance of *the plans of structure* of the animal kingdom with reference to classification, is the same thing as what Baer calls *the type of organization;* and that what he calls *the degree of perfection* in the structure of animals corresponds to the two features of their structure which I have distinguished as *modes of execution* and *degrees of complication,* after I had perceived that Baer confounds under one expression two distinct categories of structure,—one relating, indeed, to the *relative degrees* of perfection in the animal structure upon which orders are founded, but not necessarily including another, broader consideration, the *ways and means* of the execution of the plan, upon which alone classes are based. (Comp. vol. 1, p. 137–176). To some extent I have already pointed out the general homologies which unite the Echinoderms and the Cœlenterata (pp. 64–87, and pp. 99–113); but it is so difficult to trace these general comparisons through the obstructions of a confused nomenclature, and in the face of the still greater obstacles arising from the remoteness of the whole type of Radiates from that to which we ourselves belong, that a thorough appreciation of the general as well as the special homologies of these animals can only be the result of a prolonged comparative study of all their types, and an equal familiarity with all of them. I venture to say, that if Leuckart and Gegenbaur had devoted their special attention to the Echinoderms as extensively as to the Acalephs, they would feel less confident that there is a typical difference between them. As for myself, I must declare, in the words of K. E. von Baer, that I can perceive only "different degrees of perfection in their structure," and no difference "in the type of their organization;" or, in the words of my Essay on Classification, Polyps, Acalephs, and Echinoderms are built upon "one and the same plan of structure," and therefore belong to the same branch of the animal kingdom, while as classes they differ in the "modes of execution of that plan." As classes of one branch, they are held together by general homologies, while special homologies may be traced respectively in all the representatives of these classes. The most striking of these general homologies, because thus far least noticed, unquestionably, is that of the aquiferous system of the Echinoderms, and the radiating chambers of the Polyps, linked together by the chymiferous tubes of the Acalephs. It is not my intention here to trace all these homologies, to which I shall devote a special chapter in the sequel; but, since the appreciation of the true relations of the Echinoderms to the other Radiates must depend upon the views entertained of their homologies, I would urge upon the naturalists who consider the Echinoderms as a distinct type, the importance of closely comparing on one side the simpler ambulacral system of the lower Holothurians with the radiating chymiferous tubes of the naked-eyed Medusæ, and on the other side the peculiar mode of branching of the chymiferous tubes in the genus Aurelia with the ramifications of the aquiferous system in Scutella and Echinarachnius; or the radiating pouches of Cyanea, and their numerous tentacles opening freely into these cavities, with the ambulacral suckers of any Star-fish; or the circular aquiferous tube of Echinarachnius with the circular chymiferous tube of the naked-eyed Medusæ,—and I doubt not that the result of such comparisons will be a growing conviction, that the spherosome of the standing at various angles with the direction of their movements, and, what is still more perplexing, the actinal and abactinal poles of the axis are now turned one way and now the opposite way. This variability of the motions of the Acalephs renders it exceedingly difficult to describe their natural attitudes in a manner which shall not conflict with their organic structure. When at rest, Ctenophoræ assume three different attitudes, peculiar to three different types of the order: Bolina and allied genera stand in a vertical position, with the actinal pole of their main axis downward; Pleurobrachia and allied genera stand also in a vertical position, but the actinal pole of their main axis is turned upward; Idya and allied genera, on the contrary, assume a nearly horizontal position, their main axis slightly slanting, the actinal pole being lower in the water than the abactinal pole. When moving onward, in whatever direction the motion may take place, whether it be straight forward, or upward or downward, or in a circuitous course, these different types of Ctenophoræ retain the same general relation of their main axis to the surrounding medium, that is, the actinal and the abactinal poles are in the direction of the motion, the abactinal pole moving forward in Bolina, while in Pleurobrachia the actinal pole is turned forward and in Idyia obliquely backward. Besides moving in these ways by the more energetic action of the whole spherosome, the Ctenophoræ may change their position by the activity of the locomotive flappers, when the main axis may assume any direction, according to the greater or less energy, or the total inactivity, of some of the rows of these locomotive flappers, or of parts of one and the same row. In this way a slow rotatory motion may also be produced, during which the main axis may, or may not, change its direction.

It is plain from these statements, that unless a nomenclature entirely irrespective of the various positions of these animals be adopted to describe their structure and their movements, the strongest conflicts between the structural relations

Echinoderms differs only from that of the Acalephs by its hardness, that the chymiferous tubes of the Acalephs are homologous to the aquiferous system of the Echinoderms, the marginal tentacles of the Acalephs homologous to the ambulacral suckers of the Echinoderms, etc.; and once upon that track it will be easy to embrace in these comparisons all the organic systems of all Radiates, from the simplest Polyp to the most highly organized Echinoderm. As to the Ctenophoræ in particular, I have already shown (pp. 99–124) that they do not form a class by themselves, but belong to the class of Acalephs, and that they constitute one order, standing highest in that class. I cannot agree with Leuckart and Gegenbaur, who consider them as a distinct class; nor does Gegenbaur's expression appear to me correct, when he describes the digestive cavity of the Ctenophoræ as extending in the longitudinal axis of the body, if what I have stated of the morphology of Acalephs in general is true: for I hold that the main axis of all the Radiates ought to be considered as the vertical axis, around which the spheromeres are symmetrically and radiatingly arranged.

of their parts, and their attitudes, will be unavoidable, and the same motion in two different types of this order might be designated by contrary expressions. The only way of avoiding these difficulties is to adopt a nomenclature in accordance with the general homologies of these animals, and to keep in view the fact that the normal attitude of all the Radiates is that in which their main axis is placed in a vertical position. With this understanding we may then say, that, when at rest, Bolina and allied genera stand upright, with the actinostome turned downward; that Pleurobrachia also stands upright, but with the actinostome turned upward; that Idyia lies nearly horizontally, with the actinostome slanting slightly downward; and that Bolina and Idyia move with the abactinal pole forward, while Pleurobrachia moves with the actinal pole forward.

Next, we have to distinguish two other diameters, at right angles with one another and with the main vertical axis. In order correctly to appreciate the peculiar symmetry of the Ctenophoræ, it must be remembered, in the first place, that their body is made up of eight spheromeres, arranged in pairs on opposite sides of an imaginary plane dividing the whole structure into equal halves, and passing through the longer diameter of the circumscribed area of the abactinal pole, as well as through the longer diameter of the actinostome and of the digestive cavity; and, in the second place, that there are two or more distinct radiating tubes, opposite one another, and respectively intermediate between two rows of locomotive flappers, trending in the direction of another imaginary plane dividing also the whole structure into equal halves, but at right angles with the first. Thus the body of the Ctenophoræ may be divided into equal halves in two opposite directions; but the greatest diameter of these two sets of halves is not equal: that which passes, at right angles with the main axis, through the longer diameter of the actinostome and of the circumscribed area, is either greater or smaller than that which passes through the two intermediate radiating tubes, and the preponderance of the one over the other seems to be typical in different groups of Ctenophoræ. In Idyia, the transverse diameter passing through the intermediate radiating tubes is much shorter than that which coincides with the longer diameter of the actinostome; while in Pleurobrachia the relations are reversed, the transverse diameter passing through the intermediate radiating tubes being longer than the other, except that in this type the difference between the length of these two diameters is not so marked. Bolina, again, coincides with Idyia as to the respective length of its transverse diameters, and exhibits the same disproportion between the two.

We have thus, unmistakably, two different kinds of transverse diameters, though in different representatives of the order one or the other of the two kinds may be respectively the longer or the shorter. This distinction once recognized, the question arises how far one of these diameters may be considered as lateral, and the other longitudinal or antero-posterior. This question can only be answered in connection with those features in the structure of certain Radiates which exhibit more distinct traces of bilateral symmetry than the Ctenophoræ, and in which right and left become unmistakable in consequence of the presence of an odd spherosome. Such combinations exist among the Echinoderms, in which, in addition to two or more pairs of spheromeres, there is an odd one, in the direction of a plane passing through the opposite ends of the alimentary canal. And now, when it is considered that the tendency of the digestive tube to open in an excentric position coincides with the elongation of the body of Echinoderms, and that the anus is farthest removed from the mouth in those Spatangoids in which bilateral symmetry is most strikingly blended with radiation; when it is further considered, that in these animals the odd ambulacral zone coincides with the diameter along which the mouth and anus are placed, at opposite ends of the body, and that the symmetrical pairs of ambulacral zones are placed on opposite sides of that longitudinal diameter, — the conclusion seems irresistible, that the flattening of the digestive cavity of the Ctenophoræ in the direction of the longer diameter of the actinostome is the first indication among Acalephs of a tendency to form an alimentary canal in the direction of the longitudinal diameter of their body, and that the additional radiating tubes must be lateral.

Another consideration seems to militate in favor of that view. Admitting the general homology of the radiating chymiferous tubes with the ambulacral system of the Echinoderms, and that there are as many spheromeres in the body of Radiates as there are main branches of these systems, it must be apparent, that while the majority of Echinoderms have five spheromeres, the Ctenophoræ have eight; that in Echinoderms there are two pairs and an odd one, and in Ctenophoræ four pairs; and that, therefore, the zones alternating with the ambulacra in Echinoderms form also two pairs, with an odd interambulacral zone opposite the odd ambulacral zone, while in Ctenophoræ there are four pairs of zones homologous to the ambulacra, and four pairs homologous to the interambulacral zones. If, therefore, the diameter passing through the intermediate chymiferous tubes were considered as the antero-posterior diameter, there would be identical zones, that is, interambulacral zones, at both ends of that diameter; while in Echinoderms, the zone at one end of the longitudinal diameter differs from that at the other end, one being ambulacral and the other interambulacral. Now it is true, as there is no odd zone in Ctenophoræ, it may seem indifferent to consider either of their interambulacral zones in the direction of the transverse diameters as the anterior and posterior or the lateral ones; but if there is no odd zone, there is at least a substantial reason for considering the diameter which coincides with the longer diameter of the actinostome as the antero-posterior diameter, namely, the fact that in the Actinoids, in which the digestive cavity is compressed in the same manner as in the Ctenophoræ, one end of the actinostome differs in form and structure and functions from the other end, which amounts to a difference between the two ends of the compressed digestive cavity, analogous to the difference existing between the odd ambulacral and the odd interambulacral zone at the two ends of the antero-posterior diameter of the Echinoderms. I do not, therefore, hesitate in considering that transverse diameter of the Ctenophoræ which coincides with the longer diameter of the actinostome and of the circumscribed area as the longitudinal diameter of these animals, and that which traverses the body in the direction of the intermediate chymiferous tubes as the lateral diameter, and these tubes therefore as an interambulacral structure homologous to the interambulacral vesicles or tubes of the aquiferous system of the Echinoderms, and not homologous to the radiating chymiferous tubes nor to the ambulacral tubes proper. As soon as these comparisons are admitted as correct, it must be also acknowledged, further, that one of the leading peculiarities of the Radiates consists in the position of the mouth, which, instead of appearing at the anterior end of the longitudinal or antero-posterior diameter, is placed at the actinal end of the vertical diameter, or, in other words, in the centre of radiation of the whole structure.

The special structure of the Ctenophoræ readily accounts for their peculiar symmetry. Built up of eight homologous segments, their spheroidal body would approach much nearer to a sphere, the primary form of all Radiates, were these segments or spheromeres not unequal among themselves in certain directions, and again perfectly identical in every respect in other directions. Had the similarity of the structure of the Acalephs and Echinoderms been sooner traced in its details, — had, especially, the repetition of homologous segments around the vertical axis of the Acalephs, and the homology of these segments and the ambulacral zones of the Echinoderms, been perceived, — it would have been easy to recognize the foundation of their resemblance as well as that of their difference. The typical architecture of the Echinoderms depends upon the presence of five homologous zones, occasionally reduced to four, and sometimes increased to a larger number; while that of the Ctenophoræ is based upon eight homologous segments. These parts are distinguished by special homologies in their respective classes, but present an unmistakable general homology when compared to one another. When tracing these general homologies, it must, however, be remembered, that the distinction of ambulacral and interambulacral zones, introduced in the characteristics of the Echinoderms, should be discarded to the extent to which they merely express a specialization of parts peculiar to that class, since, in the Holothurians, the interambulacral zones are not more distinct than in the Ctenophoræ.

Recalling now to our mind the statement made before, that the body of the

Ctenophoræ has a vertical main axis, which is usually the greatest diameter of the spherosome, and two distinct transverse diameters, one of which is to be considered as the antero-posterior or longitudinal, and the other as the transverse, diameter proper, it will appear that the eight spheromeres are arranged in pairs upon the sides of the longitudinal diameter, in such a manner that there are two pairs upon the sides, one pair in front, and one pair behind, — one spheromere of each pair being on one side, and the other on the other side, of the longitudinal diameter. Now, in all Ctenophoræ, the spheromeres, which as pairs correspond to one another, are always equally developed and of exactly the same structure, the same size, and the same form, balancing one another completely upon the two sides of the body, so that the spherosome exhibits no trace of one-sidedness or unequal bulging, as exists in some of the Acephala. But while this is so, so long as we compare the spheromeres of one and the same pair with one another, the symmetry of the spherosome assumes a very different aspect when we extend the comparison from one pair to another pair; for while the anterior and the posterior pairs are again identical in structure, size, and form, they balance one another in opposite directions, and differ still more widely from the two lateral pairs, which also balance one another in opposite directions. These differences may be carried so far that the anterior and the posterior pair balancing one another symmetrically may be much more developed than the lateral pairs, and have a greatly modified though homological structure. The natural consequence of this peculiar symmetry is, that the anterior and posterior surfaces of the spherosome are exactly alike; and that therefore, notwithstanding the existence of a distinct antero-posterior diameter, it is impossible to determine which is its anterior and which its posterior end. For the same reason it is impossible to determine which is the right and which is the left side, even though it cannot be doubted that there are two symmetrical pairs of lateral spheromeres. We are, on that account, unable to distinguish the regions of the body of the Ctenophoræ with all the desirable precision, and shall be obliged to designate four of the spheromeres as the lateral spheromeres, and the four others as the anterior or posterior spheromeres; remembering, however, that one pair of the latter stands opposed to the other, while two single spheromeres belonging to different pairs are opposed to one another upon the sides.

The intermediate or interambulacral chymiferous tubes are always placed between two lateral spheromeres. This is a truly remarkable feature of the Ctenophoræ, unique among Acalephs, since all the other types of the class have all their spheromeres evenly balanced. We shall see presently, that this peculiarity stands in direct relation to the general mode of branching of the chymiferous tubes. I may, however, at once call attention to the bearing which this fact has upon the whole symmetry of the Acalephs. In giving prominence to the sides, it renders the bilateral symmetry of the Ctenophoræ even more conspicuous, and certainly more perfect, than in most Echinoderms, notwithstanding the presence of an odd zone in these; for as soon as the anterior extremity of the body assumes prominence by its specialization, the sides recede, as it were, to a lower relation. But in Echinoderms there is no such specialization of the anterior extremity: the structural progress of this class over the Acalephs consists only in the introduction of an odd zone. This zone is mostly identical in structure with the lateral zones, and scarcely ever so far differentiated as to give preponderance to the sides in the general configuration of the body. In Ctenophoræ, on the contrary, the absence of an odd spheromere, combined with the identity of development of the anterior and of the posterior pairs, and the differentiation of the two lateral pairs, including an additional, interambulacral chymiferous tube, throws the whole weight of the extreme structural differences of the spheromeres upon the sides, in such perfect balance with reference to the antero-posterior diameter, that the reciprocal action of the most important function in the life of these animals is to be traced in the alternate contractions of the two sides of the body. Again, the opposite poles of the main axis are strikingly contrasted: at one end we find the mouth or actinostome, and at the other end the circumscribed area, and in an asymetrical relation to it, the two discharging openings of the chymiferous system. The curves of the sides contribute also to render the contrast between the actinal and abactinal poles more prominent. Thus, in Ctenophoræ the opposite ends of their three diameters are evenly balanced, presenting identical parts in antitropic relations on the anterior and posterior sides and on the lateral sides of the body, and heterogeneous parts in similar relations on opposite poles.

As in all Radiates, the body of the Ctenophoræ is a spherosome; that is to say, it is essentially radiated in its structure, and as in all Acalephs it consists of cells, and of cells only, variously combined and of a variety of forms. There are no specialized tissues in it. The distinction of a muscular system, as described in my former papers upon Acalephs, was a mistake, as will be shown hereafter, arising from the peculiar constitution of the motory cells; nor is there a distinct nervous system. The whole bulk of the body is made up of large contractile cells, and is covered with epithelial cells, which also line the digestive cavity and the system of chymiferous tubes arising from its abactinal prolongation. The thickness and form of the spherosome vary in different families; the size and form of the digestive cavity, and the mode of ramification of the system of chymiferous tubes, also exhibit striking differences: but all Ctenophoræ agree in this, that the spherosome has a uniform structure, being made up of a continuous mass of large motory cells, combined into distinct systems, bearing definite relations to the various and complicated motions of the different parts of the body. The assumption of Mertens, that some Ctenophoræ have a mantle, which is wanting in others, is incorrect. As we shall see in the sequel, the lobe-like appendages of the anterior and posterior spheromeres of some representatives of this order are direct prolongations of the spherosome, over which the rows of locomotive flappers are extended, and to which they bear the same relations as in the more spheroidal or more cylindrical forms. The chymiferous tubes also extend uninterruptedly into these lobes, in the same manner as they extend into the peripheric parts of the plainest species. So that, whatever be the general form of the spherosome, it is one and the same body in all Ctenophoræ. Again, whatever be its form and size, the Ctenophoræ have all a compressed digestive cavity, trending in the same plane as the circumscribed area of the abactinal pole, and at right angles with the intermediate chymiferous tubes; and in all, that cavity is broadest towards the mouth and tapers in the opposite direction, its lateral walls being flattened against one another when it is empty. The narrow abactinal opening of the digestive cavity opens directly into the centre of the chymiferous system, which in all Ctenophoræ has a very peculiar mode of ramification, the general outline of which agrees in all, though marked peculiarities may be noticed in its details in different families. The most striking and characteristic features of this chymiferous system, when contrasted with that of the other Acalephs, consist in its bilateral symmetry, the axial funnel-like prolongation of its central portion, into which the digestive cavity opens directly, and the presence of two asymetrical openings at the abactinal pole, through which it discharges its contents.

Immediately beyond the abactinal opening of the digestive cavity there arise two main trunks of the chymiferous system, in opposite directions one from the other and at right angles with the plane of the digestive cavity; so that the main stems extend right and left, and almost horizontally, into the spherosome. Before dividing, each trunk sends off a vertical branch along the adjoining sides of the digestive cavity, and then divides into two nearly horizontal branches, which soon divide again; so that each trunk has four nearly horizontal or slightly inclined forks extending to the periphery, where they open into as many vertical branches, which converge in opposite directions toward the actinal and the abactinal poles. The further course of these vertical peripheric branches varies with different families; but, as far as I can ascertain, all Ctenophoræ have a chymiferous tube upon each flat side of the digestive cavity; in all, the two main trunks divide into four forks; and these eight forks open in all into eight vertical peripheric chymiferous tubes; and in addition to these, there are, in some families, other vertical and lateral chymiferous tubes arising between the lateral horizontal forks of the main trunk, which again vary in their ultimate relations in different families, lateral tentacles existing in some, and being absent in others. All these tubes, whatever be their final course, circulate the chymiferous fluid with which they are filled into all parts of the spherosome; and there is this remarkable peculiarity in the general current of this chyme circulation, that the fluid contained in one half of the body, reversing regularly its course, is alternately poured into the opposite half and back again. Thus the chief peculiarity of the chymiferous system of the Ctenophoræ does not only consist in its bilateral symmetry, but also in the antagonism of the currents of its two lateral halves.

Next, we have to notice the vertical prolongation of the chymiferous system in the shape of a funnel, extending to the abactinal pole of the body, in the prolongation of the main axis, and there, dividing into two forks, running to some distance in opposite directions, between the anterior and posterior pairs of locomotive flappers. The fork of this funnel forms a sort of cloaca, in which the refuse of the chymiferous fluid accumulates, to be at intervals discharged through two distinct openings, placed obliquely on opposite sides of the circumscribed area of the abactinal pole. The physiological significance of the circumscribed area has not yet been ascertained. It is an elongated field, circumscribed by a more or less prominent wall of vibratile fringes, interrupted in the middle by a prominent organ, considered to be an organ of hearing by some anatomists, and described by others as an eye-speck, towards which converge the abactinal prolongations of the rows of locomotive flappers.

One of the most apparent peculiarities of the Ctenophoræ, and to which this order of Acalephs owes its name, consists of eight rows of locomotive flappers, extending along the eight vertical and peripheric chymiferous tubes, with which they are closely connected. As far as I can ascertain, all Ctenophoræ have eight such rows, though some of them are represented with only four and others with twelve. But their close connection with the ambulacral tubes, and the constancy of the number of these tubes in all the Ctenophoræ which I ever had an opportunity of examining, lead me to take it for granted that the typical number of the vertical rows of locomotive flappers must be eight. I am inclined to ascribe the conflicting statements upon this point to the marked inequality observed among these rows in different families. The fact is that while they are, all eight, of equal length and equal prominence in certain representatives of this order, in others there are four larger, longer, and more prominent ones, and four shorter and smaller ones, differing more or less in their course. I hold, therefore, that the smaller rows may have been overlooked in those genera which are described as having only four rows of locomotive flappers; and that, in those which are represented as having twelve rows, the vibratile cilia of the epithelial cells lining the digestive cavity may have been mistaken for additional rows of locomotive flappers. Gegenbaur gives the same explanation of the singular figure of the Alcinoe papillosa of Delle Chiaje. The close connection which exists between the rows of locomotive flappers and the chymiferous tubes is so similar to the general organization of the ambulacral system of the Echinoderms, that I do not hesitate to consider these structures as homologous.[1]

The sexual organs of the Ctenophoræ are closely connected with the chymiferous tubes, as in all Acalephs, and, indeed, in all Radiates; for they bear the same homological relations to the radiating chambers of the Polyps, as they do to the ambulacral system of the Echinoderms. In Ctenophoræ the ovaries and spermaries occupy small pouches upon the sides of the ambulacral chymiferous tubes: spermaries and ovaries existing in all individuals, and alternating with one another in such a manner, that, while each chymiferous tube has spermaries on one side and ovaries on the other, the proximate sides of adjoining tubes have the same kind of sexual organs, that is, either spermaries or ovaries, and, alternate intervals between adjoining tubes, different kinds of organs. The mode of reproduction of the Ctenophoræ has been traced recently by Semper and McCrady; and fragments relating to the same subject have also been contributed by Vogt, Kölliker, J. Müller, and Gegenbaur. Since the publication of my paper upon Beroid Medusæ, I have had an opportunity myself of studying the entire development of Pleurobrachia, an account of which will be given in the sequel. They undergo a direct transformation, and the young very early acquire the characters of the adults.

From this general sketch of the Ctenophoræ, it may already be inferred that they constitute a very natural group among Acalephs, entirely distinct from the Discophoræ and from the Hydroids, and unquestionably occupying, as an order, the highest position in the class, if the degrees of complication of strictly homological structures are at all characteristic of orders and may determine their relative standing. Since Goldfuss first recognized the natural limits of this group of Acalephs, and Eschscholtz, with his usual precision and accuracy, characterized it as a distinct order, all naturalists have acknowledged the propriety of combining these animals into one and the same division; though some have considered them simply as a natural family, while others have raised them to the rank of a class. As I have already stated, I believe them to be an order of the class of Acalephs, and shall hold them to be nothing more and nothing less than an order, so long as there is a possibility of distinguishing families, orders, and classes upon definite

[1] Of course, in following up this homology it must be remembered that the ambulacral system of the Echinoderms is not so complicated in all of them, as it is, for instance, in the Spatangoids and Clypeastroids, or even in the Echinoids and Asterioids; for it is very simple in the Synaptoids among the Holothurians, even more so than in some Ctenophoræ, as, for instance, in Bolina. But of this, and of the special homologies of the chymiferous tubes, more presently.

principles. DeBlainville and Lesson are the only zoölogists who have associated heterogeneous types with the Ctenophoræ.

In now closing this sketch of the anatomical characters of the Ctenophoræ, I have only to add a few remarks upon some controverted points of their structure, with a view of eliciting further investigations, and preventing some mistakes from being more widely circulated. I have already stated that there exists no distinct muscular system in the Ctenophoræ. The appearance of fibres resembling muscles arises from the peculiar form of the large cells (Pl. II[a]. *Fig.* 24) forming the spherosome, about which more may be found in a subsequent chapter, where I shall also consider the true nature of the parts which, from their position and appearance, have been mistaken for nerves.

The Ctenophoræ move in two different ways; and the two kinds of motion are produced by different parts. The more energetic movements, which propel the body forward, are produced by the contraction of the various systems of motory cells hereafter to be described, and take place by jerks when they are most powerful, though during a slow, onward progress they produce a more sliding motion; besides, these animals are kept hovering in the water by the unceasing and rapid motion of their locomotive flappers. Of course, during a slow progress, the movements of these rows of flappers combine with the action of the motory cell systems, while in a more rapid progression they can contribute but little, if any thing, toward a change of place. As the mode of locomotion of the Discophoræ differs in different families according to their different form and the part their various appendages take in their movements, we must postpone a more detailed account of these differences to another chapter. Suffice it here to say, that the long tentacles of Pleurobrachia and the broad lobes of Bolina become important auxiliaries in regulating the motions of these types. That the powerful contractions of the spherosome greatly modify the form of the Ctenophoræ is now generally understood; but I would warn the student against a belief that the form of these animals is on that account less characteristic than in other animals. A bird flying has certainly a very different appearance from what it presents when at rest; but, whatever position it may assume, its form is always characteristically its own. So is it with the Acalephs in general, and, more especially, with those Ctenophoræ which are capable of performing the most diversified movements. As soon as the mode of execution of these movements is fully understood, the form preserves all its characteristics.

The chymiferous system of all Ctenophoræ requires more careful study than has generally been devoted to it. The mode of ramification of its main trunks, the form of the funnel, the course of its branches and their anastomoses, are very characteristic of the different families. That these details should have been neglected by earlier observers is not surprising; but that Gegenbaur should have published a figure and description of a new Cydippe, without noticing the course of these tubes and the connection of the tentacles with this system, is unpardonable, the more so since he positively affirms that that species, Cydippe hormiphora, has not only a hollow tentacle, but that the peculiar cirrhi attached to it are also hollow, and communicate with the cavity of the tentacle. If these tentacles were truly hollow, it would be of the highest interest to know in what way the interambulacral tubes penetrate into their cavity, and what are the relations of the currents extending into these tubes to the general circulation of the chymiferous fluid through the whole system; since in Pleurobrachia the interambulacral tubes do not extend beyond the base of the tentacular apparatus, and the tentacles are not hollow. It may be that there are two types in the structure of these interambulacral or tentacular tubes, as there are two types of tentacles among the naked-eyed Medusæ, some being hollow, as in Sarsia, and others plain, as in Bougainvillea; but, until the connection of the tentacular cavity of Cydippe hormiphora with the interambulacral tubes, and the connection of these with the central cavity of the chymiferous system, be more fully ascertained, the statement of Gegenbaur remains unsatisfactory. That a current through the tentacles is not a necessary condition of their extraordinary power of extension and rapid contraction, is plainly seen by the fact, that the tentacles of Sarsia, which are hollow, are neither more active, nor, comparatively to their size, more extensively movable, than those of Bougainvillea, which are full. Milne-Edwards has mistaken the bulb of the tentacular apparatus of LeSueuria for a secretory organ, and erroneously considered it as discharging its contents outward. It is certainly closed, and no more open than the interambulacral dilatations of the radiating tubes of Aurelia, which Ehrenberg also erroneously described as opening outward, and performing the functions of multiple anal apertures. I have carefully examined these swellings in Bolina, LeSueuria, and Aurelia, and am certain, that, unless they are accidentally injured, they in no way communicate with the surrounding medium. That these tentacular tubes are interambulacral, and not ambulacral, is at once settled by their position, since they are intermediate between the radiating tubes extending to and communicating with the vertical, peripheric, ambulacral tubes; but they are homologous to the simple radiating tubes arising in Aurelia from the angles of the sexual cavity, and enlarging in the margin into the little pouches mistaken by Ehrenberg for cloacas, and supposed by him to open outward through as many anal apertures as there are such interambulacral radiating tubes. The tentacles connected with these tubes are therefore also interambulacral, and on that account cannot be considered as homologous to the simple ambulacral tentacles of Sarsia, or to the bunches of tentacles of Bougainvillea. We shall see presently, that the lasso cells of the tentacles of the Ctenophoræ differ also greatly from those of the Discophoræ. I shall take occasion to consider more minutely the direction of the sac containing these interambulacral tentacles, when describing the Cydippidæ in detail. The homologies of the whole chymiferous system of the Ctenophoræ and Discophoræ being thus fully established, it would be idle to animadvert further upon the comparisons which have been made between the Ctenophoræ and Tunicata: their resemblance is merely analogical. There is, however, one point in the structure of the Ctenophoræ, which, in this connection, deserves further consideration.

I have already alluded to the homology of the whole chymiferous system of the Acalephs, and the ambulacral system of the Echinoderms. A careful study of this homology may throw some additional light upon the true nature of the black speck in the centre of the circumscribed area of the Ctenophoræ, and upon the significance of the area itself. Remembering that the eye-specks, or whatever the organs at the peripheric end of the ambulacral zones of the Echinoderms may be, are placed at the tip of the rays in the Star-fishes, and in the Sea-urchins on the abactinal side of the spherosome, alternating with the ovarial plates; remembering, further, that similar sensitive specks are placed at the tip of the ambulacral chymiferous tubes in the Discophoræ, while there is but one such speck in the centre of the axial prolongation of the funnel in the Ctenophoræ, — the conclusion seems unavoidable, that the broad expansion of the abactinal surface of the Discophoræ corresponds to the broad field occupied by the dorsal surface of the Star-fishes, and that therefore the eye-specks of the Discophoræ are not only homologous to the eye-specks of the Star-fishes, but also occupy a homological position in the periphery of the spherosome, while in Ctenophoræ the single eye-speck has a homological position with the five eye-specks of the Sea-urchins at the abactinal pole of the spherosome, with this additional peculiarity, that in Ctenophoræ there is but one single eye-speck, and that there are five in the Sea-urchins. Such a Cyclops-like fusion of the eyes occurs in other types of the animal kingdom, and is not unfrequent in the Crustacea; it cannot be an objection, therefore, to such a homology. Moreover, the single eye-speck of the Ctenophoræ is closely connected with the chymiferous system, as the many eye-specks are in the Discophoræ and Echinoderms; and that connection, in accordance with the central position of the eye-speck, takes place in the axial prolongation of the system.

Whether these sensitive specks are to be considered as eye-specks, or as auditory organs, is another question, which also requires our consideration. Strictly speaking, they are not homologous to either eyes or ears, if the mode of development of these organs of the senses in Vertebrates is considered; nor can they be compared to the eyes or ears of the Articulates, since in the former the higher organs of the senses are prolongations of the lateral evolutions of the brain, combining with involutions from the surface, while in the latter they are modifications of the lateral appendages of the annular elements of the body of these animals. Whatever be the real functions of these controverted organs in the Radiates, one thing is certain, — they are all modifications of the ambulacral tubes connected with the ambulacral tentacles. This homology is readily ascertained by a careful comparison of the so-called eye-specks of the Discophoræ, especially those of Aurelia (Pl. IX. *Figs.* 3 and 4); and if the homology I have attempted to trace between them and the eye-specks of the Echinoderms and the single speck of the Ctenophoræ, in the centre of the circumscribed area, is correct, then all these organs,— whether eye-specks or auditory bags, whether simple pigment cells upon the surface of the tentacles, or vesicular cavities, including various concretions and apparently independent of the system of tentacles, — are homologous modifications of one and the same apparatus throughout the whole type of the Radiates, and constitute organs with more or less specified functions, possibly analogous to the functions of seeing and hearing in the other branches of the animal kingdom, but certainly built upon a different plan, congruent with the idea of radiation, which pervades them all. Gegenbaur states that he has looked in vain for the eye-speck in Eurampliæa. Is it possible that this genus should present such a departure from the universal structure of its type? It does not appear probable to me.

Having thus far traced the special homologies of the sensitive organs connected with the chymiferous system, I would suggest, that, if the comparisons I have made are correct, it becomes probable that the circumscribed area of the abactinal pole of the Ctenophoræ corresponds to the line encircling the dorsal surface of the Star-fishes, or the narrow field included between the abactinal termination of the ambulacral zones in the Sea-urchins. Whether the fringes of the edge of the circumscribed area of Beroe correspond in any way to the marginal tentacles of the Discophoræ, as McCrady suggests, or not, I am not prepared to say. If the homology I assign to the area itself is correct, it would scarcely be possible to homologize its marginal fringes with the marginal tentacles of the Discophoræ, since these are themselves homologous to the ambulacral suckers.

Gegenbaur has correctly homologized the lateral auricles of the Mnemiidæ, in comparing them to the anterior and posterior lobes of that type, only he should have added that there is, however, this structural difference between them, that while two spheromeres, with their ambulacral tubes and rows of locomotive flappers, combine on the anterior and on the posterior side of the spherosome, to form one anterior and one posterior lobe, each lateral spheromere has its independent auricle, so situated that while those of one side are the mates of those on the other side, those of the same side stand also in antitropic relation to one another. Their structure does not justify the supposition that the auricles are strictly homologous to the marginal tentacles of the Discophoræ; but, at the same time, it should not be overlooked that they are a prolongation of the ambulacral tubes of their sphoromeres, and to that extent they bear homological relations to the marginal tentacles of the Discophoræ.

Remote as the comparison may seem, it cannot be doubted, upon reflection, that the simple radiating tubes of the naked-eyed Medusæ and those of the medusoid individuals of the Siphonophoræ are strictly homologous to the ambulacral tubes of the Ctenophoræ, as they are also to those of the Discophoræ proper. Their number generally coincides in the Ctenophoræ and higher Discophoræ, though there are only four in the Siphonophoræ and most Hydroids proper. Sometimes they are, however, very numerous in the latter, as we frequently find an indefinite repetition of identical parts in the lowest representatives of almost every type.

We have already seen that the peripheric branches of the chymiferous system do not open outward, as Ehrenberg and Milne-Edwards supposed; but there are, unquestionably, openings in its axial prolongation, in Ctenophoræ, which have generally been considered as anal apertures. Milne-Edwards has accurately described them in LeSueuria, and they have been observed by all later investigators. Lesson alone has mistaken accidental openings in the circumscribed area for structural features. There can be no doubt of his mistake, since he describes those holes in the Beroids proper as surrounded by fringes, while the position of the natural openings of the abactinal pole of the Ctenophoræ is outside of the area, as well as outside of the fringes which encircle it. In all the Ctenophoræ which I have examined, I have invariably found two such openings, in an excentric position, one on one side and the other on the other side of the antero-posterior diameter, and obliquely opposite to one another. Gegenbaur states that there is only one such opening in the species which he has examined with reference to this point. It is much to be regretted that he should not have mentioned its position; for if the opening which he saw was excentric, as I have always found these openings to be, I should infer, that while he saw one gaping and shutting, the opposite one may have remained closed, as it sometimes does for a considerable length of time. Gegenbaur further affirms that water may be admitted into the system through that opening. I have only seen the openings gaping to discharge parts of the contents of the funnel, and never observed an inward current of the surrounding medium. But whether these holes are simply discharging openings, or at the same time afferent apertures also, it is equally important to consider their relations to the whole system more fully than has generally been done.

The Ctenophoræ are very greedy, and do not spare their own kindred; but, generally, they feed on different kinds of Acalephs and a variety of small marine animals, which they digest very rapidly. I have seen an Idyia swallow a Bolina nearly as large as itself and consume it in half an hour, rejecting the more consistent parts, such as the locomotive flappers, etc. During the process of digestion the funnel is greatly distended, and the chymiferous tubes swell enormously, so that their diameter much exceeds the width of the rows of locomotive flappers, and an active circulation may be traced through the whole system, when even the most minute branches appear gorged with fluid. Undoubtedly this fluid is subservient to the purpose of alimentation; and the whole body enlarges, and, when full-grown, derives its maintenance, through what it assimilates out of it. But when considering its relations to the whole organism of the Ctenophoræ and the part it plays in their general economy, it should not be overlooked that it is neither blood, nor in any way comparable to the fluid circulating in the vascular system of either the Vertebrates, the Articulates, or the Mollusks, but simply a fluid elaborated in the digestive cavity by a disintegration of the food, with which a large quantity of water is mixed, and then, after the coarser parts have been rejected through the mouth, directly poured into another cavity, the funnel, whence it passes into the radiating tubes, parts of it being from time to time discharged through the two openings near the abactinal pole.

In consequence of these very peculiar combinations, it is not easy to ascertain what these openings are. Some anatomists unhesitatingly call them anal apertures; but the anus, throughout the animal kingdom, is the posterior opening of the alimentary canal, while here we have two openings in the central part of a system which is distinct from the digestive cavity, and through which nutritive fluid is circulated. These openings cannot, therefore, be identified with anal apertures, even though the nutritive mass be only chyme, and neither chyle nor blood; but ought to be considered as a special structural combination peculiar to this type of the animal kingdom. It cannot be strictly homologous to any structure among the higher types of animals; and the nearest resemblance which it has to the structural complications of the Vertebrates is a mere analogy, and may be thus expressed: Supposing the alimentary canal and the lymphatic vessels arising from its wall to be in direct and open communication with the veins which carry the products of digestion to the heart, and through this with the arteries providing the materials that are discharged by perspiration at the surface of the body, and that the fluids moving through this succession of distinct structural systems should be throughout the same fluid, and the channels through which it is discharged at the surface, not only unobstructed by intervening capillary networks, but uniform from one end to the other, and we should have homological structures. The difference between the one and the other case shows the remoteness of their analogy; and, instead of calling these openings *anal apertures*, I would prefer the name of *cœliac apertures.*

The motions of the chymiferous system are of two kinds. The tubes themselves are distended by the influx of the fluid elaborated in the digestive cavity, and their diameter is reduced by the contractions of the cells forming the spherosome. The alternate currents from one half of the body to the other and vice versa are also the result of the alternate contraction of the opposite halves of the spherosome; but the slower flow of the fluid through the chymiferous tubes, and especially its undulating motions, now in one direction and then in the opposite direction, within comparatively short tracks of the tubes, are unquestionably determined by the vibratile cilia which line their inner surface.

For the same reasons, I am not inclined to consider the colored cells lining in vertical rows the walls of the abactinal portion of the digestive cavity as homologous to liver cells. No doubt they are analogous to a liver; but, to be homologous with such a complicated glandular organ, they should derive the fluid they contain from bloodvessels, and not from chymiferous tubes. As pigment cells do not occur at the surface of all Ctenophoræ, but only in some of their representatives, I shall describe them in their proper place.

In our temperate latitudes the Ctenophoræ are annual animals, laying their eggs in the autumn and then dying, and the young brood making its appearance in the spring. I have watched the species of the coast of Massachusetts during twelve successive years, and invariably found that in the earlier part of the summer the majority of specimens observed were small and destitute of sexual organs, or, at least, not yet filled with eggs and spermatic cells, as they are later in the season. The largest specimens are always seen during the last summer months, and all disappear after the autumnal gales. The sexual organs of the Ctenophoræ are described by some anatomists as sexual glands, and called ovaries and testes, according to the sexes. While I retain the name of ovaries for the female, and propose that of spermaries for the male organs, I must record my objection to the use of the word *gland* to designate these organs. A glandular sexual organ can only exist in animals which have a distinct vascular system, through which blood is circulated; and this is not the case in the Acalephs. Here again the reproductive organs are only analogous, and not homologous, with the organs performing the same functions in the higher animals. In Ctenophoræ they are simple pouches or lateral sacs of the chymiferous tubes, and have no special walls distinct from those of the tubes with which they communicate. The actinal disposition of the sexual organs is another peculiarity of the Radiates, which distinguishes them strikingly from similar organs in other types of the animal kingdom. It should also be remembered, that hermaphroditism is not very uncommon among these animals, in which case the male alternate with the female organs in their radiated arrangement. Among Polyps, we have such a combination in Cerianthus:

among Acalephs, in the Ctenophoræ generally. I have never observed hermaphrodites among Echinoderms.

McCrady has described facts which he considers indicative of a fissiparous multiplication of the Ctenophoræ. What I have seen of the persistence of parts of the body of Ctenophoræ has rather appeared to me as indications of the protracted vitality of disconnected parts of these animals. When injecting Ctenophoræ, I often had occasion to make incisions into their spherosome, and I have always been struck with the power with which these wounds were closed up, by the contraction of the surrounding cells, but never observed a healing process. I have often cut Ctenophoræ and other Acalephs into halves, or into smaller segments, without materially interfering, for some time at least, with the manifestations of their vitality. Idyias cut into halves in any direction continued to live in my jars as long as uninjured specimens. I even once saw half of an Idyia close over a small Bolina and digest it, its cut edges overlapping its prey. It seemed to me, sometimes, as if mutilated individuals fared even better in confinement than entire ones. I am certain that this is the case with larger Discophoræ. I never succeeded in preserving large specimens of Cyanea entire in my tanks for more than two days; but, after cutting off all their long tentacles and their oral appendages and dividing the disk into halves or quarters, I have often preserved such segments for weeks, swimming about as if uninjured, when entire specimens caught at the same time would die and decompose in one or two days. But I never saw the slightest trace of reproduction of lost parts.

In order to avoid the difficulties which, in describing species, might arise from a strict adherence to a nomenclature based upon homologies, it would seem advisable not to use the expression *vertical axis* or *vertical diameter* to designate the main axis of the Radiates in general; for the very obvious reason, that that axis is oblique in a very large number of Echinoderms, as, for instance, in the Spatangoids. I would, therefore, prefer the use of the word *actinal axis* or *actinal diameter*, as expressing the axis which unites the actinal and the abactinal poles. The diameter which passes through the longer diameter of the actinostome and corresponds to the *longitudinal diameter* of the Spatangoids had better be called *cœliac diameter*, because it is not, obviously, the longest diameter; though in all Radiates, in Polyps as well as in Acalephs and Echinoderms, it trends in the direction of the digestive cavity, or of the main cavity of the body. The name *cœliac*, moreover, does not imply the necessity of distinguishing the anterior and posterior ends of a longitudinal diameter, which in Acalephs do not differ, as they do in some Echinoderms. For the diameter which, homologically speaking, I have designated as the *transverse diameter*, I would prefer the name of *diacœliac* diameter, as it stands in rectangular relation to the *cœliac* diameter.

SECTION II.

SUBDIVISIONS OF CTENOPHORÆ, FORMING SUB-ORDERS.

A comparison of the various attempts to subdivide the Ctenophoræ is very instructive with reference to the principles upon which classifications may be based. Eschscholtz,[1] as early as the year 1829, divided them into three families: CALLIANIRIDÆ, with the genera Cestum, Cydippe, and Callianira; MNEMIIDÆ, with the genera Eucharis, Mnemia, Calymma, and Axiotima; and BEROIDÆ, with the genera Beroe, Medea, and Pandora. Mertens admits four families: Cestums, Callianiras, Beroes, and Idyas. Lesson, who considers the whole order as a family under the name of BEROIDEÆ, subdivides them into eight tribes: *Cestoideæ*, with the genera Cestum and Lemniscus; *Callianireæ*, with the genera Callianira, Chiaia, Polyptera, Mnemia, Bucephalon, and Bolina; *Leucothoeæ*, with the single genus Leucothoea; *Calymmeæ*, with the genera Calymma, Eucharis, Alcinoe, LeSueuria, and Axiotima; *Neisidæ*, with the genus Neis; *Ocyroeæ*, with the genus Ocyroe; *Cydippæ*, with the genera Mertensia, Anais, Eschscholtzia, Janira, and Cydippe; and the *Beroæ* proper, with the genera Beroe, Idya, Medea, Cydalisia, and Pandora: to which, strange to say, a number of Diphyidæ, Tunicata, Noctiluca, and Bipinnaria, are added. Leuckart, who considers them as a distinct class, subdivides them primarily into two orders, the Eurystomata and Stenostomata. Gegenbaur admits five families, which he groups under three heads: 1°, those the body of which is extended into lobes, with or without tentacles, the *Callianiridæ* and *Calymnidæ*; 2°, those which have no lobes,

[1] When considering the works of a master in any department of Natural History, I am in the habit, first, of identifying myself with his views as completely as I possibly can, and ascertaining how far, in the course of the progress of our science, additional evidence may have been accumulated in support of his opinions, even if the new facts should tend at the same time to modify them; for it is generally the case, that those who have been long engaged upon a difficult subject instinctively perceive relations which become more apparent only with the lapse of time. Next, I proceed to a critical revision of the bearing of each fact, in order to avoid one-sided appreciations and useless discussions. And, finally, I present the result of my own investigations, combined with the information thus obtained from the labors of my predecessors. This method I have found particularly useful in the study of the Acalephs, most of which are described in so many different ways by different authors and at different periods, with such unequal knowledge of their structure, that, unless we supply the deficiencies of older writers by the light cast upon these animals from modern investigations, a large number of the most interesting types of the class would have to be entirely left out of consideration in our renewed attempts at tracing their natural affinities.

but always tentacles, the *Cestidæ* and *Cydippidæ;* and 3°, those without lobes and without tentacles, the *Beroidæ.*

Here, as everywhere in our science, the total absence of a principle in assigning a rank to the divisions adopted by different authors is painfully felt. While Eschscholtz considers the Beroids as an order, to which he first applied the name of CTENOPHORÆ, Lesson considers the whole group simply as a family, with which he unites most heterogeneous animals, belonging to several distinct classes; and Leuckart, whom Gegenbaur has followed in that respect, regards them as a distinct class. The three families distinguished by Eschscholtz coincide very closely with the three more comprehensive groups into which Gegenbaur arranges the five families which he admits. Mertens, again, separates Cestum from Cydippe, as a distinct family, unfortunately retaining the name Beroe for the family of the latter genus, and applying that of Idyia to the family called Beroideæ by Eschscholtz and that of Callianira to the family called Mnemiidæ by Eschscholtz, who had already used the name Callianiridæ for the family to which he refers the genera Cestum, Cydippe, and Callianira. It is in view of this confusion, probably, that Gegenbaur has again changed the family name of Mnemiidæ *Esch.* to Calymnidæ *Gegenb.*; but in so doing he has only made the matter worse, since his family Calymnidæ again differs from the tribe called Calymmeæ by Lesson. This affords another evidence of the absolute necessity of strictly adhering to the law of priority. The family names first proposed by Eschscholtz cannot be discarded so long as there remains a natural group of Ctenophoræ to which they can be applied. We shall see presently what is the value of the eight tribes distinguished by Lesson. The first question that should now engage our attention is, whether the families adopted by Eschscholtz and Gegenbaur bear family characters or not; since I have already shown that the Ctenophoræ, as a natural group, are neither a class, as Leuckart and Gegenbaur admit, nor a family, as Lesson would have it, but a natural order of the class of Acalephs.

Eschscholtz assigns the following characters to his three families of Ctenophoræ: *Callianiridæ,* with small digestive cavity and tentacles; *Mnemiidæ,* with small digestive cavity, but without tentacles; *Beroidæ,* with large cavity of the body acting as digestive cavity. Gegenbaur characterizes his families as follows: *Callianiridæ,* with lateral, wing-like appendages supporting the locomotive flappers; *Calymnidæ,* with two lobe-like appendages upon the sides of the mouth; *Cestidæ,* body riband-like, expanding transversely; *Cydippidæ,* body oval or rounded; *Beroidæ,* body ovally elongated. The characters assigned by Eschscholtz to his families are entirely derived from their structure, without reference to form: Gegenbaur, on the contrary, distinguishes some of his families by anatomical characters, others by their form. Which of these two methods is correct? for I mean, at present, only to consider the method, and not the value, of the characters assigned to the groups themselves. Inasmuch as Gegenbaur has introduced the element of form in the characteristics of his families, instead of alluding solely to the features of their structural complication, as Eschscholtz had done, he has made a decided advance over the classification of the latter. This is the more apparent when it is remembered that these structural complications are not at all overlooked by him; but, on the contrary, are made use of in grouping the families under three more comprehensive heads, to which, however, he has assigned no names, but which correspond very closely to the groups called families by Eschscholtz. It is proper, therefore, that we should inquire into the meaning of these groups, and at the same time remember also that Leuckart likewise admits divisions among the Ctenophoræ superior to the families, which he calls orders, and of which he admits two, — the EURYSTOMATA and STENOSTOMATA, the former corresponding to Eschscholtz's family Beroidæ, the latter to Eschscholtz's united families Callianiridæ and Mnemiidæ; admitting, further, that the Ctenophoræ are a class and not an order. We have thus, as subdivisions of Ctenophoræ, *three families* distinguished by Eschscholtz, corresponding to *three higher divisions, including five families* admitted by Gegenbaur, and *two orders* admitted by Leuckart.

With these facts before us it cannot be difficult to untie the knot of these conflicting views, only leaving, for the present, the question of the natural limits of all these groups out of consideration.[1] Leuckart and Gegenbaur have evidently both felt that the natural families of the Ctenophoræ are linked together by features of a more comprehensive value than family characters; but, placing only a subordinate importance in questions of classification, one of them has given no names to the groups based upon those features, while the other has called them orders. If, as I have urged again and again, families are based upon peculiar patterns of form, and orders, natural groups founded upon the degree of complication of the structure, the characters assigned by Gegenbaur and Leuckart to these divisions are truly of the kind upon which orders are founded; but, the characters of orders resting upon the sum of structural complications which determine their relative standing in the class, it is plain that special points in that complication which do not extend to all the members of the order can only lead to the recognition of secondary natural groups sharing the characteristics of orders, but not themselves orders, and for which I have proposed the name of *sub-orders.*

[1] In all discussions like the present, a perfect familiarity with the objects themselves is a necessary requirement; for if the natural features of these objects are first to be ascertained during the discussion and by the study of a given classification, there is an end to every critical inquiry into the importance and relative value of the characters assigned to the divisions adopted by different authors, and the meaning and rank of the divisions themselves.

This once settled, it remains to be seen how many such sub-orders there are among Ctenophoræ, and what is the range of their structural peculiarities, and next to ascertain in the same way the number and natural limits of the families in each of these natural groups.

As Gegenbaur has already noticed, Leuckart has based his primary subdivisions of the Ctenophoræ upon a character of comparatively little value,—the dimensions of the digestive cavity. It is nevertheless true, that the group thus separated from the other types under the name Eurystomata is a very natural one, already distinguished by Eschscholtz, to whose family of Beroidæ it exactly corresponds, as well as to Gegenbaur's third group of Ctenophoræ, without lobes and without tentacles. There is therefore no discrepancy among naturalists as to the existence of a natural division among Ctenophoræ, including the species most closely allied to the genus Beroe of Brown. Eschscholtz recognizes it as a family under the name of Beroidæ; Mertens as a family under the name of Idya; Lesson as a tribe under the name of Beroæ; Leuckart as an order under the name of Eurystomata; and Gegenbaur as one primary division of the Ctenophoræ including the only family of Beroidæ. But while all agree upon the limits of that group of Acalephs, there is the widest discrepancy among them as to its rank and standing in the class.

In attempting to decide between these conflicting opinions, it must be borne in mind, that, in analyzing the characteristic features of these Beroids, we have to consider different categories of characters. In the first place, the Beroe proper have all those structural peculiarities in common with the other Ctenophoræ, which, from their complication, place them highest in the class of Acalephs as a distinct order. But, though agreeing with the Ctenophoræ generally in the complication of their structure, they differ from all other Ctenophoræ in one striking anatomical character, entirely independent of their peculiar form,—*they have no interambulacral chymiferous tube*, which exists in all others. The existence of two parallel chymiferous tubes in the transverse plane of some Ctenophoræ, on both sides of the digestive cavity, was first pointed out by Milne-Edwards in his admirable description of LeSueuria vitrea (Ann. Sc. Nat. 2e sér. vol. 16, p. 203, Pl. 3, *Fig.* 1 *h* and *j*). Will has described them in Eucharis multicornis (Horæ tergestinæ, p. 31, Pl. I. *Fig.* 3, *b* and *c*). I myself have traced them in Bolina (Mem. Am. Ac. IV. Pl. 7, *Figs.* 4, 7, and 8). Gegenbaur, however, mentions and figures only one of them. As they are easily confounded, on account of their parallel course, I have no doubt that he must have confounded them. One is deeply seated, close to the digestive cavity, and communicates with the tube encircling the mouth; the other is more superficial, and quite at the surface, near the mouth. They are best seen facing the anterior or the posterior surface of the animal, as their divergence is thus brought into view. In the attitude in which Gegenbaur has represented his Euramphæa vexilligera, they cover one another, as they then lie in the same plane. In order readily to designate these two tubes, which are eminently characteristic of the Mnemiidæ or Calymnidæ, I shall hereafter designate that which follows closely the outline of the digestive cavity as the *stomachal* or *cœliac chymiferous tube*, and call that which lies outside, the *interambulacral* or *tentacular chymiferous tube*. Now, the structural peculiarity of the Beroids proper consists in having a very large stomachal or cœliac chymiferous tube opening into an equally wide oral tube (Pl. II. *Fig.* 10), *whilst the interambulacral* or *tentacular tube is entirely wanting*. The centre of the whole chymiferous system, its main trunks and the axial funnel, is remarkably small in comparison to the wide ambulacral, cœliac, and oral tubes.

There are other secondary anatomical peculiarities, equally characteristic of this group, which may now be mentioned also. The eight ambulacral chymiferous tubes are equally developed; there is no difference in the extent or size or structure of those running along the sides, or along the anterior and posterior surfaces; they all give out numerous, rather conspicuous, and highly ramified branches, while the cœliac tube is entirely destitute of ramifications. The ovaries and spermaries (Pl. II. *Fig.* 4, and Pl. I.), the special arrangement of which has already been described above, are large and very conspicuous at the spawning season. The circumscribed area (Pl. I. *Fig.* 3, and Pl. II. *Fig.* 9) is encircled by a prominent wall of elegantly branched fringes.

The structural character bearing more directly upon the form of this group of Ctenophoræ consists chiefly in the even thickness of the spheromere (Pl. I. *Figs.* 3 and 4), which renders it movable in every direction; so that the changes of outlines of the Beroids proper are far more extensive than those of any other members of the whole order. This ability to change their form is further enhanced in these animals by the circumstance, that the digestive cavity extends so far towards the abactinal pole as to reduce the bulk of the spherosome in that direction to the average thickness which it has upon the sides. A comparison of the different figures of Pl. I. may give some idea of these changes of form; and *Fig.* 10, especially, which represents a specimen of the same size as *Figs.* 7 and 8 gorged with a Bolina nearly of its own size, will show to what extent they may be distended. *Fig.* 5 represents a specimen with the actinostome turned inside the digestive cavity. Notwithstanding this remarkable movability, all these animals preserve a very regular and symmetrical form in a state of rest, the sides appearing uniformly compressed.

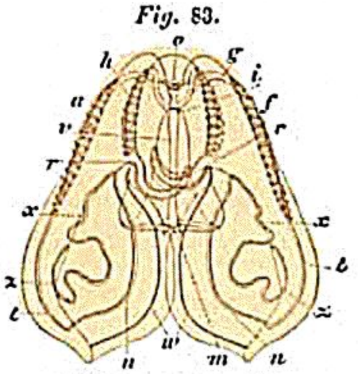
Thus we have here two different categories of characters: first, anatomical peculiarities of the same kind as those upon which the order of Ctenophoræ is founded, only relating to certain limited points of their structure; and, secondly, a distinct pattern of form determined by the even thickness of the spherosome, or, more accurately, by the even arrangement of the motory cells of the spheromeres. I hold, therefore, that the Beroids proper constitute a distinct sub-order, and not merely a family nor a distinct order, since their distinguishing characters, though of the kind of those upon which orders may be founded, do not extend to their whole organization. We shall see presently whether these Acalephs constitute only one single family, or not.

It would be tedious, were I to analyze at the same length the value of all the characters upon which are founded the other subdivisions of the Ctenophoræ proposed by different naturalists. Suffice it for me to say, the division proposed by Leuckart under the name of Stenostomata is neither an order, as he takes it, nor a natural sub-order, — not simply because the characters which he assigns to these Ctenophoræ are not of the kind upon which orders may be distinguished, but because it is in itself a heterogeneous assemblage of different types. The groups designated by Eschscholtz as two distinct families, and the corresponding groups proposed by Gegenbaur, under which he unites respectively the families of the Callianiridæ and Calymnidæ, and the Cestidæ and Cydippidæ, approach much nearer to the idea of sub-orders. At all events, they include the representatives of two distinct sub-orders; but, from want of personal acquaintance with the Callianiridæ and Cestidæ, I am unable to state with certainty how closely these may be allied to the types of the two sub-orders which I have investigated. It may also be noticed, that Eschscholtz and Gegenbaur disagree as to the affinities of Cestum and Callianira, — Eschscholtz uniting both with Cydippe, while Gegenbaur separates them as types of distinct families. So, leaving for the present the question of the closer affinities of the genera Cestum and Callianira out of consideration, I am prepared to show that Eschscholtz's Mnemiidæ and his Callianiradæ do not constitute two natural families, but two distinct sub-orders equivalent to that of the Beroids proper. On account of the questionable affinities of the genera Callianira and Cestum, I am, however, compelled for the present to designate one of these sub-orders by a different name from that applied to it by Eschscholtz, and shall adopt for it that of Cydippidæ, instead of Callianiridæ.

The anatomical peculiarities of the Cydippidæ, which show them to be a sub-order, and not merely a family, correspond exactly to those which distinguish the Beroidæ. The eight ambulacral tubes are equal or nearly so, as in Beroidæ, but they terminate, on both sides of the main axis, at a considerable distance from the poles of the spherosome, and do not open into an oral tube; for there is no such circular chymiferous tube around the actinostome in this group of Ctenophoræ. The cœliac tubes are very large, and terminate as blind sacks upon the sides of the actinostome. Neither the ambulacral nor the cœliac tubes give out conspicuous ramifications. But while the peripheric part of the chymiferous system is thus limited, its central part is more fully developed than in any other Ctenophoræ; the main trunks and their eight forks are very large, and the axial funnel is equally wide. The most conspicuous structural feature of the Cydippidæ consists in the presence of *two extensive tentacular organs, one on each side,* attached at the bottom of a deep sack, along the proximal surface of which extend *two large parallel chymiferous tubes,* homologous to the one simple interambulacral tube of Bolina, already mentioned above. The chief differences in the distribution of the chymiferous system of the Beroidæ and Cydippidæ consist, therefore, not only in the limitation of its peripheric branches, the absence of an oral tube, and the broad development of its centre, but also in the presence of a double interambulacral or tentacular tube on each side. The ovaries and spermaries are very small in comparison to those of the Beroidæ, and the circumscribed area of the abactinal pole, covered with vibratile cilia, is simply limited by a narrow ridge. The deep and wide sac containing the tentacular apparatus, and the bilateral disposition of the main trunks of the chymiferous tubes, combined with their ample dimensions, have a powerful influence in controlling the form of these animals. But we shall consider this point more fully when discussing the characters of the different families of Cydippidæ.

The sub-order of the Mnemiidæ is at once distinguished by the *unequal development of the ambulacral tubes* and *of the locomotive flappers,* and by *the presence of two more or less extensive lobes,* formed by a peculiar expansion of the spherosome. Of the eight ambulacral tubes there are four, the two lateral pairs, which are antitropically symmetrical to one another and identical in form and extent with one another, but differ greatly from the four others, the anterior and the posterior pairs, though these are also symmetrical and identical among themselves. When contrasted with one another, these two sets of tubes present very peculiar combinations. In the first place, the anterior pair, which faces the posterior pair, or vice versa, is separated from the latter by two pairs of lateral tubes, so arranged, however, that one tube of each pair is on one side, and the other tube of each pair on the other side, of the cœliac diameter or plane, which may divide the anterior as well as the posterior pair of tubes into equal halves; and not so placed that one pair would be on one side and the other pair on the other side, though at first sight it would seem as if four pairs of tubes were placed crosswise to one another. A correct appreciation of the peculiar symmetry of the Ctenophoræ is so difficult, that, even at the risk of being tedious, I must try to make clear the arrangement of these tubes by another explanation. Calling one side the right, the other the left side, and one of the connecting surfaces the anterior and the other the posterior, we find that one of the tubes of the anterior pair is on the right side, and the other on the left side; next to these we have on each side one of the tubes of the first lateral pair, which may be called the anterior lateral pair; next, on each side, one of the tubes of the second lateral pair, the posterior lateral pair; and, finally, opposite to the anterior pair, on each side, one of the tubes of the posterior pair: so that the two lateral tubes of the same side do not form together one pair, but are each the counterpart of those on the opposite side. (A comparison with Pl. VII. of my paper in the Mem. of the Amer. Ac. may readily render this intelligible. See also the adjoining *Figs.* 83, 84, 85,

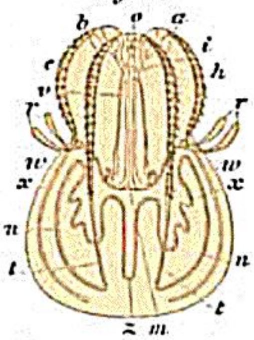
Fig. 83.



BOLINA ALATA, Ag.
(Seen from the broad side.)

a and *f* Long rows of locomotive fringes. — *g* and *h* Short rows of locomotive fringes. — *o* Central black speck (eye-speck ?). — *i* to *m* Triangular digestive cavity. — *i* to *o* Funnel-like prolongation of the main cavity. — *v* Chymiferous tube of the tentacular apparatus. — *m* Tentacular apparatus on the side of the mouth. — *r r* Ear-like lobe, or auricles, in the prolongation of the short rows of locomotive fringes. — *t t* Prolongation of the vertical chymiferous tubes. — *n n* The same tubes turning upwards. — *x x* Bend of the same tubes. — *z z* Extremity of the same tubes meeting with those of the opposite side. — *w* Recurrent tube anastomozing with those of the auricles.

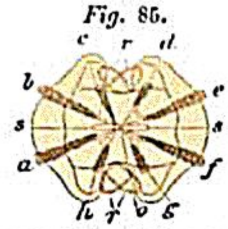
Fig. 84.



BOLINA ALATA, Ag.
(Seen from the narrow side.)

a b Long rows of locomotive fringes. — *c h* Short rows of locomotive fringes. — *o* Central black speck (eye speck ?). — *i* Upper end of the digestive cavity. — *i* to *o* Funnel-like prolongation of the main cavity of the body. — *m* to *i* Digestive cavity. — *r r* Auricles. — *m* Mouth. — *t t* Prolongation of the vertical chymiferous tubes. — *n n* The same turning upwards. — *x x* Bend of the same tubes. — *z* Anastomosis of the two longitudinal tubes *t t*. — *w w* Recurrent tube, anastomozing with those of the auricles. — A comparison of this figure with *Fig.* 83 gives a distinct idea of the relative position of the digestive cavity *m* to *i*, and the chymiferous tubes of the tentacular apparatus *v*.

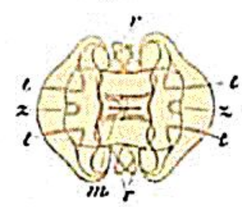
Fig. 85.



BOLINA ALATA, Ag.
(Seen from above.)

o Central black speck (eye speck ?). — *a b e f* Long rows of locomotive fringes. — *c d g h* Short rows of locomotive fringes. — *r r* Auricles. — *s s* Circumscribed area of the upper end of the body.

Fig. 86.



BOLINA ALATA, Ag.
(Seen from below.)

m Mouth. — *r r* Auricles. — *t t t t* Prolongation of the vertical chymiferous tubes. — *z z* Anastomosis of these tubes.

and 86.[1]) All other Ctenophoræ have their ambulacral chymiferous tubes arranged in the same way as in the Mnemiidæ, only that their combinations are not so readily

[1] *Fig.* 85, which represents our Bolina from the abactinal pole, will best explain these relations. The line *s s* indicating the longitudinal or cœliac diameter, the ambulacral rows *a*, *h*, *g*, and *f* of one side are the counterparts of those marked *b*, *c*, *d*, and *e* of the other side; *a* and *b* being the anterior pair, and *f* and *e* the posterior pair; *h* and *c* the anterior lateral pair, and *g* and *d* the posterior lateral pair. *Fig.* 86, representing the actinal pole in the same position, shows the continuation of the same rows, or their tubes, on this pole. *Fig.* 83 represents one side of the animal in profile, but in the same position as *Fig.* 85, so that the rows *a*, *h*, *g*, and *f* alone are visible, which correspond to the rows *a*, *h*, *g*, and *f* on one side of the cœliac diameter in *Fig.* 85. *Fig.* 84, finally, represents the anterior surface of the same specimen, so that here the anterior pair of rows *a* and *b*, and the anterior lateral pair *c* and *h*, are alone visible; that is to say, the rows on one side of the diacœliac diameter, corresponding to the rows *a* and *b* and *c* and *h* of *Fig.* 85.

perceived, on account of the great uniformity of the tubes themselves. Even in Pleurobrachia, in which the chymiferous tubes seem absolutely identical in size, and evenly radiating in eight directions, the same arrangement may be recognized, upon careful examination.

In the second place, these four pairs of chymiferous tubes, so combined, are unequal in their development, — the lateral pairs being short, and terminating each in a small free lobe or auricle, while the anterior as well as the posterior pair, meandering through the thickness of lobe-like prolongation of the spherosome, anastomoze with one another, and form a curious lattice-work of chymiferous tubes upon the inner surface of the base.[1]

The most striking peculiarity of all the ambulacral chymiferous tubes of the Mnemiidæ consists, however, in the great inequality of the diameter of the tubes in different parts of their course. Upon the sides of the spherosome, and as far as the locomotive flappers extend along with them, they are wide and highly contractile; but beyond these limits they are more like capillary vessels of an equal diameter, especially in their prolongation upon the inner surface of the great lobes of the spherosome, where those of the two sides of the anterior and of the posterior pair anastomose with one another, as well as with branches from the lateral pairs and from the oral tube. The centre of the whole chymiferous system is neither so fully developed as in the Cydippidæ nor so reduced as in the Beroidæ; but the main trunks and the axial funnel are of moderate dimensions. The cœliac and the interambulacral tubes, of which there is but one on each side, run parallel to one another, and present nearly the same development. The tentacular apparatus is connected with the extremity of the interambulacral tube, but not enclosed in a deep sac. The circumscribed area of the abactinal pole is not more distinct than in the Cydippidæ, nor are the ovaries and spermaries prominent. The digestive cavity is comparatively small, as in Cydippidæ; but there is this remarkable difference between the Mnemiidæ and Cydippidæ in the relations of the actinostome, that while in Cydippidæ the mouth is prominent on the actinal pole, in Mnemiidæ the broad lobes formed by an actinal prolongation of the two anterior and the two posterior spheromeres extend far beyond the mouth, and may

[1] Whether this network of chymiferous tubes, thus far only noticed in Bolina, Alcinoe, Chiaja, and Leucothoe by Mertens, Will, and myself, exists in all Mnemiidæ, or not, I am unable to say. I am, however, inclined to believe that it will be found in all. Its anastomosis with the recurrent tube of the auricles seems a typical indication of its natural connections; and as the recurrent tube has been observed in LeSueuria and Eurampliæa, I infer that the rectangular, anastomotic ramifications of the chymiferous tubes upon the lower surface of the lobe-like prolongation of the spherosome is likely to exist in all the representatives of this sub-order. The appearance of this network of tubes is very similar to the mode of ramification of the branchial vessels of the Naiades.

cover it entirely, when brought together by an antitropic movement, in the direction of the antero-posterior diameter. The relative size of these lobes, as well as of the auricles, at the actinal end of the lateral chymiferous tubes, varies greatly in different representatives of this sub-order, but the lobes and auricles exist in all; in all there are four auricles, one to each lateral chymiferous tube; and in all there are only two lobes of the spherosome, each formed by the combination of two spheromeres. The locomotive flappers are limited to the compact part of the spherosome, the lateral ones being generally much shorter than the anterior and posterior ones. In no Ctenophoræ is the bilateral symmetry more prominently marked than in the Mnemiidæ; and when the lobes of the spherosome are fully extended, the cœliac diameter greatly exceeds the diacœliac diameter.

To these three sub-orders I would refer all the Ctenophoræ I know; and unless Cestum proves to have marked structural peculiarities not described by the naturalists who had an opportunity of examining that genus, it must be referred to the Cydippidæ, with which Eschscholtz has already associated it. I believe, however, that Cestum is likely to prove the type of a distinct sub-order, if the account given by Eschscholtz and Mertens of its chymiferous tubes is at all correct. But the circumstance that both have overlooked the cœliac tube, which exists in all Ctenophoræ, lessens my confidence in their description. The figure of Vogt is still more defective, as it also omits the interambulacral tube which Eschscholtz represents. The most striking difference between Cestum and the true Cydippidæ, to which Eschscholtz refers this genus, consists, according to the figures I have examined, in the trend of the tentacular sac, which in Cestum is in the direct prolongation of the interambulacral tube, and opens on the actinal side of the spherosome, while in Pleurobrachia it is bent in the opposite direction and opens on the abactinal side. There can be no question on that point. LeSueur,—who has published the first figure of Cestum,—Eschscholtz, Mertens, and Vogt, all represent it in the same position, in illustrations which are not copied one from the other, and even represent different species. All the authors who have described Pleurobrachia represent that apparatus in this genus as I have myself seen it, trending in the opposite direction, with the sole exception of Grant, who erroneously represents it in a reverse position, in a paper specially intended to illustrate a nervous system which is wanting. This mistake may show the importance of studying minutely the symmetry of these animals.

Another peculiarity of Cestum, mentioned by some naturalists who have observed this genus, is the presence of only four rows of locomotive flappers along the abactinal side of the elongated spherosome: this is the statement of Eschscholtz. Vogt represents such flappers on both sides of the animal, and says expressly (Zool. Briefe, p. 257) that they exist upon all the margins of the body.

As to the dimensions of Cestum, Vogt calls width what is truly the height of the animal; LeSueur, Cuvier, Blainville, Mertens, and Gegenbaur apply the same designation of width to the surface which has the longest diameter, and which Vogt correctly calls length; the transverse diameter, or that which measures the thickness of the tape-like body, being the shortest diameter. A comparison with Pleurobrachia or Bolina, taking the relative positions of the actinal and abactinal poles and of the interambulacral tubes into consideration, will at once set this matter right. But it is obvious that this genus requires reëxamination with reference to the general course of its chymiferous tubes and the number of rows of its locomotive flappers. I have no doubt that the chymiferous tubes which follow the rows of locomotive flappers on both sides of the elongated abactinal pole are the two anterior and the two posterior ambulacral tubes, and those which Eschscholtz has described as median tubes, the four lateral ambulacral tubes; but it remains to be ascertained whether these tubes are entirely destitute of locomotive flappers or not. From the figure of Eschscholtz, I suspect that each row of locomotive flappers may correspond to a double row, as in young Cydippidæ. If this should be the case, Cestum would truly form a fourth sub-order, characterized, in addition to these structural peculiarities, by the trend of its tentacular sac, and the extraordinary development of its anterior and posterior pairs of spheromeres. The natatory flappers of the actinal margins described and figured by Vogt are likely to be homologous to the auricular fringes of the Mnemiidæ.

As to Callianira, judging from the descriptions and figures thus far published, it would seem to be but slightly different from Pleurobrachia, and therefore to belong to the sub-order of Cydippidæ; but as no recent investigator had an opportunity of examining any species of that genus since the structure of the Ctenophoræ has begun to be better known, it is impossible to form a decided opinion upon its affinities. I merely infer its Cydippian relationship from the position of the tentacles in Callianira triploptera. The most striking character assigned to it consists in the wing-like projection of the rows of locomotive flappers, of which there are three pairs, according to the descriptions, though the figures show that there must be four pairs.

Thus far, I have designated the different sub-orders of the Ctenophoræ by the name of the best-known family belonging to each; but as these names will have to be retained for the families themselves, it is necessary now to select some others for the sub-orders. For the Beroidæ the name *Eurystomæ*, or *Eurystomata*, applied to them by Leuckart, may be retained; for the Cydippidæ I would propose that of *Saccatæ*, on account of the deep pouch in which the tentacular apparatus is received; and with Eschscholtz (Isis, 1825, p. 741), that of *Lobatæ* for the Mnemiidæ, on account of the lobe-like prolongation of the spherosome. Should Cestum prove the type of a distinct sub-order, these Ctenophoræ may be called *Tæniatæ*. A few Acalephs referred to the order of Ctenophoræ do not belong to it at all; such are the Beroe Gargantua *Less.*, which is a genuine Discophore, and the Acils *Less.*, which are mostly Siphonophoræ. Berosoma *Less.* may be a Pyrosoma; but since it was described and figured from memory, it hardly deserves further notice till it has been observed satisfactorily.

It may now be asked how far these sub-orders may be superior or inferior to one another. This is a question which I am not fully prepared to answer. Indeed, it seems as if natural sub-orders exhibit fewer indications of superiority or inferiority among themselves than any other kind of natural divisions in the animal kingdom, the characteristic features of sub-orders resting chiefly upon the prominence of one or the other subordinate elements of the structural complication which distinguishes the order itself. We find, for instance, that while the interambulacral chymiferous tube is wanting in the Eurystomæ, they have a large oral tube, which is wanting in the Saccatæ; but these have a complicated tentacular apparatus with a double interambulacral tube, all of which is wanting in the Eurystomæ: and again, the Lobatæ have four auricles and two lobes of the spherosome, which do not exist in either the Saccatæ or the Eurystomæ, but in the Lobatæ the oral tube is small and the tentacular apparatus very imperfect in comparison to that of the Saccatæ. So that, unless comparative embryology some day furnishes the means of determining the relative importance of these structural differences, it is not likely that these sub-orders can be linked together in a gradual series, without falling back upon arbitrary considerations for their systematic arrangement.

McCrady, who has admitted as sub-orders the same divisions which Leuckart calls orders, does not hesitate to consider the Beroids proper as superior to the tentaculated Ctenophoræ. It seems to me that his argument is untenable. The reduction in the number of identical parts is truly a character of superiority, and the absence of tentacles in the Ctenophoræ Eurystomæ might be an indication of their superiority, if the tentacles of Ctenophoræ were homologous with the tentacles of Discophoræ; but I have proved that they are not, their position showing distinctly that they are an interambulacral, and not an ambulacral, apparatus. Their limited number in some Ctenophoræ, and their total absence in others, are therefore not to the point. I am rather inclined to assign to the Beroids proper the lowest position, on account of that very absence of tentacular apparatus, the presence of which in Saccatæ and Lobatæ I view as an additional structural complication; and, judging from Mr. McCrady's own statements respecting the embryology of Bolina, which I have not myself traced, I would assign the highest position to the Lobatæ, on account of their resemblance to the Saccatæ during the earlier stages of their growth, and the later development of those peculiarities which distinguish the Lobatæ as a sub-order. Indeed, the facts already ascertained respecting the embryonic growth of the Ctenophoræ seem to justify the inference, that while the Eurystomæ are the lowest, the Lobatæ are the highest, and the other sub-orders occupy an intermediate position between them; for the prominence of the anterior and posterior spheromeres over the lateral pairs and their lobe-like prolongation in the Lobatæ are characters not observed in the earliest stages of their development, and marking therefore a progress which, not being reached by the other sub-orders, assigns the highest position to the Lobatæ. Again, the amplitude of the cœliac cavity and of the chymiferous tubes in the very young Lobatæ coincides with the essential character of the Eurystomæ. So that, if the development of Cestum should not interfere, it would be natural to arrange the Ctenophoræ in the following order: Eurystomæ, Saccatæ, Tæniatæ, and Lobatæ.

CHAPTER SECOND.

THE NATURAL FAMILIES OF THE CTENOPHORÆ.

SECTION I.

FAMILY CHARACTERS IN GENERAL AMONG CTENOPHORÆ.

SINCE it is probable that hereafter the natural families of animals may be characterized by a distinct category of structural features, and with greater precision than before, in accordance with suggestions I have already made in the first volume of this work (p. 155), I will only add here a few remarks upon the manner in which I conceive that this should be done in the class of Acalephs. The characteristics of the families require a thorough revision throughout the animal kingdom; for, of late, it has been customary among naturalists simply to select some prominent genus among those which appeared closely related, and, giving its name a patronymic termination, to call family almost any kind of combination of genera associated under such a head, sometimes even without assigning to such would-be families any characters at all. There are many hundred families now recorded in descriptive works of Zoölogy which have no better foundation than this, and a great many more to which characters are assigned in no way bearing upon the features upon which natural families may be founded. This state of things should no longer be tolerated; or, at least, if such loose proceedings cannot be prevented in our science, they should no longer be received as contributions to its advancement. It is one thing to give a family name to an arbitrary association of animals, and quite another thing to investigate the structural features upon which a family may be founded. If the essential character of a family consists in the typical form of its representatives, it becomes a scientific problem in Zoölogy to ascertain what are the structural features which determine their peculiar pattern; and I hold, that, to characterize a natural family correctly, it is not sufficient to describe the mere outlines or the figure of its representatives, but it is indispensable to point out the structural elements which determine the particular form, characteristic of the family under consideration. I may add, from the attempts I have made to characterize the natural families of different classes of animals, that this is one of the most difficult tasks a zoölogist can undertake; but I am at the same time satisfied, from the results at which I have already arrived, that it is one of the most profitable sources of new and interesting discoveries.

It may perhaps be objected, that the limitation of families depends, in a great measure, upon preconceived views; and that naturalists disagree entirely in their estimate of the natural range of most of them. This is undoubtedly the case at present; but let those who think that they may divide animals as they please, conscientiously try to distinguish the different categories of characters of those classes of animals with which they are particularly familiar, and they will soon perceive how much this method will improve their studies, and how easily order will replace the chaotic accumulation of characters which are generally given as diagnoses of the groups they consider, whether they apply themselves to the description of species or genera or families or orders or classes or branches. And as to families in particular, they will soon find out how fully the term form, understood as the pattern of a definite figure, expresses the general character of families; and they will also be made to feel how difficult it is correctly to investigate the essential elements of these family forms, and what extensive anatomical investigations are required before a single one can be satisfactorily described. An acquaintance with the changes which animals undergo during their embryonic growth is particularly useful in this kind of investigations. In Ctenophoræ, the family characters rest chiefly in the various combinations of the different systems of motory cells which make up the bulk of the spherosome.

Another objection may perhaps be raised upon the ground, that if every modification in the form of animals is to be considered as the basis of a distinct family, the number of families will be increased beyond measure. Supposing, for a moment, it were so; if the investigation of the structural elements determining the form should reveal to us, in the course of time, an unexpected number of structural patterns unknown at present, this would be a decided gain for science, and not an objection to our method. But I may say that nothing of the kind is to be apprehended, if I may judge from those classes to which I have thus far paid the most special attention. The analytical method I propose has in most cases only helped me to define with greater precision, families already pointed out or partially characterized, and in a few instances only rendered necessary the further subdivision of certain families and the reunion of others. In this connection, it is of the highest importance to remember that the independence of any natural group in the animal kingdom can in no way be determined by the number of its representatives. The Squirrels and Mice are very numerous in comparison to the different families of Edentata or of Pachyderms; the Warblers or Herons are very numerous in comparison to the Ostriches or Pelicans; the Snakes and Lizards are very numerous in comparison to the Turtles or Toads; the Perches, the Mackerels, and the Suckers are very numerous in comparison to the Sharks and Skates, etc. But all the natural groups founded upon a knowledge of many of them are no more natural than if their existence had been ascertained from a careful examination of a single representative of each. The history of our science affords ample evidence to substantiate this assertion. The genus *Esox*, as limited by Linnæus, contains nine species, every one of which is now referred to a distinct genus: *Esox Lucius* has become the type of the genus *Esox* proper; *Esox Belone*, the type of the genus *Belone; Esox brasiliensis*, the type of the genus *Hemirhamphus: Esox Vulpes* belongs to the genus *Butirinus; Esox Synodus*, to the genus *Saurus; Esox Hepsetus*, to the genus *Engraulis*[1]; *Esox gymnocephalus*, to the genus *Erythrinus: Esox Sphyræna* has become the type of the genus *Sphyræna;* and *Esox osseus*, the type of the genus *Lepidosteus.* These nine genera are referred by some ichthyologists to four different families, and by others to eight distinct families. Now, if either Linnæus or Artedi had carefully studied the species in their time referred to the genus *Esox*, they might have recognized the different genera to which they were afterwards referred, quite as well as Lacépède or Cuvier, or any other ichthyologist; and they might even have perceived the necessity of separating some of them more widely than they were in the days of Cuvier, since, as I have shown, Lepidosteus differs greatly from all the other living fishes.

But, to come to the point I am aiming at. The genera Belone, Hemirhamphus, Saurus, Engraulis, Butirinus, Erythrinus, Sphyræna, and Lepidosteus, could as truly have been separated from *Esox* by Linnæus with the aid of that one species he knew of each, as they can be characterized now that we know many species of all of them; and, upon a discriminating discussion of their differences, they might have been characterized, not only in the same way as they are now in most works, but even with greater precision. What is needed for such systematic work is accurate knowledge of the animals before us, and not a large number of species; though it is true that we derive additional aid, and our task is made comparatively easy, when we become acquainted with many closely allied species, leading, by their near affinity, to a readier perception of their generic relations.

[1] I do not mean to enter here into a critical controversy as to the true affinities of this species, nor of two other Linnæan species of the genus Esox, which have also led to extensive discussions among ichthyologists: for my purpose, one view of the case is as acceptable as another.

If genera and families exist at all in nature, the genera above mentioned, and the families to which they have been referred, or some other divisions more or less nearly approaching them, really exist; and the discrepancies between the statements of Linnæus, Cuvier, and Müller, respecting their affinities, will have nothing to do with the existence of the groups to which they belong, when their natural limits shall be ascertained beyond controversy. The differences now so generally prevailing among naturalists respecting the circumscription of the groups they adopt do not arise, in my opinion, from inherent difficulties in the subject, but from the circumstance, that, in defining groups of any kind, zoölogists are too ready to snatch at the first feature which strikes their eye and seems to afford a ground for distinction, without making themselves thoroughly acquainted with the whole range of peculiarities of the animals they study, and then sifting the different categories of their characteristic features to lay the foundation for a durable edifice. As soon as genera and families and the higher divisions of animals begin to be studied with the view of ascertaining the nature of their difference, and no longer simply as means of classifying species, we shall hear no more of the unmeaning complaints about *making* too many genera, or about *useless* genera, and the non-existence of genera and families and the real existence of species, and the like; but shall enter upon an era of truly scientific studies in systematic zoölogy.

SECTION II.

THE NATURAL FAMILIES OF THE CTENOPHORÆ EURYSTOMÆ.

There is a much greater uniformity among the representatives of the Ctenophoræ Eurystomæ than among either the Saccatæ or Lobatæ; and it is not easy to ascertain whether they all belong to one family or not, for the simple reason that very few of them have been examined with the minuteness now required in the investigation of Acalephs. There is, in fact, a single figure among the many thus far published, and representing Beroids proper, which gives an accurate idea of the structure and form of one of these Acalephs, and that is nearly twenty years old; it accompanies Milne-Edwards's highly instructive paper on Acalephs, in the Annales des Sciences naturelles for 1841. What the other illustrations are intended for may be guessed at; but it is impossible with certainty to refer them to their respective species, or to ascertain the peculiarity of the species by a comparison of the figures, and the descriptions are generally neither better nor more instructive than the plates. This state of things is the more to be lamented, since these Acalephs are among the most delicate known, and so frail that it is utterly impossible to preserve them for any length of time, in alcohol or any other fluid. Direct comparisons of species inhabiting distant regions are therefore out of the question; and all that can be done in attempting to arrange them systematically is to infer their true characteristics and affinities from the scanty information furnished by various authors. Milne-Edwards justly remarks, that, in the present state of our knowledge, it would be difficult to point out any real differences between the Beroe of the Mediterranean and those observed in the Antilles, in the northern Atlantic, about the Cape of Good Hope, and in the South Seas. As I have had frequent opportunities of examining two very different American species of this type, I feel in a measure prepared to call attention to the characteristic features of these animals.

As Milne-Edwards has already shown, the Beroids proper are not broadly open at both ends; and there is only one free communication with their main cavity, at the actinal pole. The opening mentioned by Cuvier, Delle Chiaje, and Lesson as existing at the opposite pole, is either an illusion resulting from the inversion of the abactinal end of the spherosome, or the result of an accidental perforation of that region. The form of the body varies greatly in different states of contraction; but under all its changing aspects, it is easy to perceive that the characteristic form is that of a compressed egg, truncated at one end, at which the mouth is situated. The chief differences among extreme forms consist in the greater or less extension of the actinal axis, in the more or less tapering of the abactinal or of the actinal pole, the blunter or the narrower end of the body being at opposite poles in different species, and in the compression of the lateral spheromeres. The prominence of the abactinal ends of the lateral spheromeres, while the anterior and posterior spheromeres may be depressed in the direction of the circumscribed area, constitutes another element of the differences noticed in the form of these animals. In all the representatives of this sub-order the oral opening is truncate, with the sole exception of Lesson's Idya dentata, from the western coast of Africa, which is represented from a sketch by Rang (Acal. Pl. II. *Fig.* 3) as deeply indented between the rows of locomotive flappers, and having a tentacle projecting from the angle of each indentation. If this is really so, and not the result of laceration, this species should be considered as the type of a distinct genus, forming a distinct family. The circumstance that Lesson was indebted to Rang for the drawing he published, strongly favors the supposition that we have here the first indication of a distinct genus, forming by itself a family of the Ctenophoræ Eurystomæ, distinct from the Beroids proper. For this genus I would propose the name of Rangia, in memory of the distinguished author of important contributions to the natural history of the Ctenophoræ, and call the family RANGIDÆ.

Notwithstanding Lesson's assertion to the contrary, I see no reason why the genus Neis *Less.* should be removed from the immediate vicinity of the Beroids proper and brought into close relationship with Mnemia. Every word in the description of that beautiful Acaleph bearing upon its structure, coincides with the impression made by the figure published in the Zoologie de la Coquille, Pl. XVI. *Fig.* 2, in strengthening the conviction that Neis belongs to the Ctenophoræ Eurystomæ. It has the wide mouth and truncated oral margin, and the vascular reticulation throughout the spherosome; and if the anterior and posterior spheromeres seem to project like the lobes of the Ctenophoræ Lobatæ, a careful analysis of the description, compared with the figure, will show at once that the interambulacral space between these spheromeres alone differs from the rest of the surface of the body in being more brightly colored, but that they do not form a lobe-like expansion, nor are there tentacular tubes or auricles, which exist in all the Mnemiidæ. While I am convinced, therefore, that Neis belongs to the Eurystomæ, I am not quite so sure that it should not be considered as the type of a distinct family, the NEISIDÆ *Less.*; for Lesson expressly states that the abactinal pole is not only much more compressed than the actinal, but also deeply emarginate, and thus giving the whole body a wedge-shaped and heart-shaped form, which can scarcely be the result of the same arrangement of the motory cells as exists in the Beroids proper, the body of which is thinner at the actinal pole. According to his figure and description there is also a marked difference in the disposition of the rows of locomotive flappers, which are nearly equal in the true Beroids; while in Neis the anterior and posterior pairs are much longer than the lateral pairs, and converge towards the circumscribed area, the lateral ones converging towards one another. If these traits are not in themselves family characters, they seem at least to indicate family differences. Gegenbaur erroneously refers Neis to the family of the Cydippidæ.

The *Beroids* proper as a family would then embrace the species thus far referred to the genera Beroe, Idya, Cydalisia, Medea, and Pandora, subject to a critical revision of their closer affinities. The names Beroæ and Beroidæ, it is true, were first introduced by Goldfuss and Rang to designate the whole order of Ctenophoræ, and then limited by Eschscholtz and Lesson to the Ctenophoræ Eurystomæ; but if Neis and Idya dentata *Less.* constitute distinct families, the family of BEROIDÆ will in the end only embrace those Ctenophoræ Eurystomæ whose body is evenly compressed laterally and provided with nearly equal rows of locomotive flappers,[1] the regular forms of which arise from the even distribution of the radiating and

[1] In all regular rounded or slightly compressed Ctenophoræ, the equality of the rows of locomotive flappers is only nominal. A searching comparison discloses in all these Acalephs, even in the most

concentric systems of motory cells in all the eight spheromeres. It is impossible to read the true family characters of the Rangiidæ and Neisidæ in Lesson's indifferent descriptions, and but for the familiarity I have acquired with the different types of Acalephs, I should not have ventured to point them out at all; but I hope, in this way, to call the attention of naturalists more directly to these curious species. However, while I indulge in this piece of presumption, I feel compelled to repeat a remark already made elsewhere, that the difference between characterizing a family by its peculiar structural form and simply pointing out its existence and probable differences should never be lost sight of. When considering the North American species of this type, we shall also examine how far Gegenbaur is correct in referring all the true Beroidæ to a single genus, Beroe *Brown*. Meanwhile, I would only call attention to the fact, that Lesson has referred to this genus many species which belong to the family of Cydippidæ, and were mistaken by him for genuine Beroidæ, because the specimens he noticed had lost their tentacles: such are most, if not all, his Béroés Mélonides.

We have thus three families of Ctenophoræ Eurystomæ: the BEROIDÆ proper, the NEISIDÆ, and the RANGIIDÆ, one of which only — the Beroidæ — is satisfactorily known.

SECTION III.

THE NATURAL FAMILIES OF THE CTENOPHORÆ SACCATÆ.

As was shown in a preceding section, the Ctenophoræ Saccatæ constitute a natural sub-order, corresponding to the genera Callianira and Cydippe of Péron and Eschscholtz, to the families Callianiridæ and Cydippidæ of Gegenbaur, and to the tribe Cydippæ, and part of the tribe Callianiræ, of Lesson. We have now to consider the natural limits of the families of this group.

The genus Callianira of Péron, from which Eschscholtz derived the name of his family Callianiridæ, — in which, besides Callianira, he includes Cydippe and Cestum, — has not been observed for more than half a century. Our knowledge of these Acalephs is therefore limited to the few and rather indifferent statements included in the characteristics of the genus as described by Péron, and some other remarks,

uniformly arched, an unquestionable difference between the anterior and the posterior rows on one side and the lateral rows on the other side; and a practised eye cannot fail to perceive a marked difference in the curve of corresponding rows of the same pair among the anterior and posterior ones, as well as among the proximate lateral rows of the same side.

equally meagre, by Slabber and Modeer. The figure published by Péron is rather indistinct; and it is impossible to determine with certainty whether the Acaleph he had before him when he named that genus belongs to the same type as the two species afterwards referred to it by Eschscholtz. That Péron himself did not appreciate correctly its structural peculiarities is plain, from the fact that he referred the genus Callianira to the Pteropods and not to the Acalephs. Eschscholtz never had an opportunity of examining a species of this genus, though it was he who referred to it the other two nominal species now associated with the Callianira of Péron. Judging from the figures adduced under the names of Callianira triploptera and C. hexagona, there can be no doubt that the genus Callianira belongs to the Ctenophoræ Saccatæ, since they exhibit two long lateral tentacles, occupying the same position as those of Pleurobrachia; and were not the descriptions unanimous in representing the rows of locomotive flappers as extending along prominent ribs upon the sides of the spherosome, I should not hesitate to refer the genus Callianira to the same family as the genus Pleurobrachia: but since the surface of Pleurobrachia is nearly even, and the locomotive flappers are never raised into wing-like appendages, I am inclined to believe that when Callianira is observed again it will be found to constitute the type of a distinct family closely allied to Pleurobrachia, but chiefly distinguished by the prominent development of the rows of motory cells which underlie the vertical chymiferous tubes. That no Callianira can have only six or four rows of locomotive flappers,[1] as might be inferred from their descriptions, is already plain from an inspection of the figures of Slabber copied by Brugière in the Encyclopédie Méthodique. The descriptions seem to have been made without remembering that the middle rows visible in the figure must have been repeated on the opposite side. Should the structure of these species, when examined again in the light of our modern knowledge of the Acalephs, prove to constitute a family by themselves, the name of CALLIANIRIDÆ must be restricted to them. Should it on the contrary appear that they cannot be separated from Pleurobrachia, which with its allied genera now constitutes the family of Cydippidæ, then this name must be suppressed, and the united Cydippidæ and Callianiridæ retain the name of Callianiridæ.

Gegenbaur, perceiving the inappropriateness of uniting the genera Cestum, Cydippe, and Callianira into one family, has called the species included in the genus

[1] The distinctive differences noticed by Eschscholtz in the diagnoses of the species of Callianira seem rather to indicate an inequality in the development of the spheromeres, than a difference in their number, and, therefore, probably mark a generic difference among them, already acknowledged by Eschscholtz, who, in the Isis for 1825, p. 742, adopts the genus Sophia *Pér.* for the Callianira diploptera, by the side of the genus Callianira *Lamk.* for the C. triploptera.

Cydippe of Eschscholtz Cydippidæ, and at the same time pointed out two groups among these Acalephs, which seem to me to constitute in reality two distinct families. To one of these groups he refers the compressed species, of which the Eschscholtzia cordata of Kölliker is the type; to the other, he refers the more rounded species, of which the Cydippe Pileus of Eschscholtz is the type. But, in enumerating the species which he would associate with the latter, he mentions those which are quite as remarkable for their compressed form as the Eschscholtzia cordata. We have therefore to make a preliminary survey of the whole group before we can proceed any further in characterizing this family. It is obvious that when Eschscholtz characterized the genus Cydippe he had chiefly round or oval species in view, the only ones belonging to this type he ever saw. It is, further, unquestionable that his genus Cydippe is synonymous with Pleurobrachia of Fleming, and that, since Pleurobrachia is the older name, it must be retained. The plea entered by Eschscholtz for discarding it, rests on a mistake: Fleming did not call his genus Pleurobranchæa, but Pleurobrachia, on account of its lateral arms, and it can never be confounded with Pleurobranchæa, so named on account of its lateral gills. The name Cydippe must therefore be dropped as a generic name, though there is no objection to retaining it as a family name. The genus Mertensia *Less.*,[1] which Gegenbaur would suppress, is a good genus, as remarkable for its lateral compression as Eschscholtzia cordata, and therefore not belonging strictly to the type of Cydippe. The genus Eschscholtzia *Less.* was established for round species. It was therefore a mistake on the part of Kölliker to refer his Eschscholtzia cordata to it. We shall see hereafter, that the genus Janira *Oken* also contains oval species belonging to the Cydippidæ proper, and that several other species, referred either to Eschscholtzia or Cydippe, constitute also distinct genera of that family.

What I have already said is sufficient to show that Gegenbaur was on the

[1] Lesson has made a singular mistake in naming this genus, which he intended to dedicate to the oldest observer of the species he regards as its type. Now, the oldest observer of this arctic Acaleph is not H. Mertens, the naturalist of the Russian exploring expedition in the Seniavin, but Friderich Martens, of Hamburg, the precursor of Scoresby in the exploration of the seas of Greenland and Spitzbergen, whose work was printed in 1675, and whom Lesson quotes again and again as Mertens. I shall therefore make good the mistake of Lesson, and compensate for his error, by calling another genus of the same family Martensia, the type of which was first observed by H. Mertens, and described by the latter under the name of Beroe octoptera. It is much to be regretted that Gegenbaur should have overlooked the claims of Mertensia *Less.* to a distinction as genus, and on that account proposed to transfer the name Mertensia to another type. But this cannot be done, not only because the genus Mertensia *Less.* must stand, but also because the transfer of one generic name to another genus, even when that name has become vacant, leads to confusion, instead of simplifying our scientific nomenclature. The rule I insist upon here is of long standing.

right track when he began to subdivide the Cydippidæ into two distinct groups, and he was only prevented from carrying out his suggestion to its legitimate limits by insufficient materials. Taking the rounded forms of Cydippidæ as the representatives of the limited family of that name, and the compressed ones as the representatives of another family, for which I would propose the name of Mertensidæ, we may now proceed to a comparative survey of the distinguishing characters of the two.

The CYDIPPIDÆ proper are remarkable for the striking similarity of their eight spheromeres. There is so little difference between them, that though I have been familiar with one representative of this group for a great many years, and though I have kept hundreds alive annually for weeks in succession, it was not until recently that I perceived how, under this seemingly perfect radiation, the same antitropy of the spheromeres may be recognized which characterizes the most compressed types of Ctenophoræ, in which bilateral symmetry is most prominent. Here, then, as in all Ctenophoræ, there are an anterior and a posterior pair of spheromeres and two lateral pairs, and the direction of the circumscribed area and of the actinostome marks the direction of a plane which may divide the body into equal lateral halves; and here, as in all the Ctenophoræ, the cœliac and the tentacular chymiferous tubes trend in another plane, at right angles with the preceding. Their apparent equality, however, and their symmetrical radiation, combined with the presence of two lateral tentacles protruding in the direction of the abactinal pole, constitute the most striking character of the family, to which the following genera belong: Pleurobrachia *Flem.* (Cydippe *Esch.*), Janira *Oken*, Eschscholtzia *Less.*, and Mertensia *Gegenb.*, for which I would substitute the name Dryodora, since Lesson's genus Mertensia must be retained. To these I would add the genus Hormiphora for Gegenbaur's Cydippe hormiphora. Lesson's genus Anais[1] must be suppressed. Gegenbaur erroneously refers the genus Ocyroe *Rang* to the family of the Cydippidæ: it belongs to the Ctenophoræ Lobatæ.

MERTENSIDÆ. A very ostensible character of this family consists in the flatness of the sides of its representatives. But this is a more apparent than real peculiarity; for in animals, whose spherosome is extensively movable in every direction, a slight lateral compression vanishes from sight whenever the body is greatly expanded or contracted. Yet the structural combination which determines that flatness is not only a permanent, but also a very striking, characteristic, readily

[1] It is with deep regret that I feel compelled to lay the unsparing hand of criticism upon a monument of parental affection erected by Lesson to a beloved child; but the genus Anais cannot stand in our science. It is founded upon a young Acaleph, described by Sars as Cydippe quadricostata, and probably the immature state of his Mnemia norvegica, as McCrady suggested, after tracing the embryonic growth of his Bolina littoralis. He also regards Will's Cydippe brevicostata as immature.

distinguishing the Mertensidæ from the Cydippidæ proper. As we have seen, the spheromeres of the Cydippidæ are so uniform in their size, structure, and radiated arrangement, that their conformity to the type of the Ctenophoræ, in their bilateral disposition, is barely perceptible: in the Mertensidæ, on the contrary, the anterior and posterior spheromeres are very different in their form and size, and even in their structure, from the lateral ones, so that the bilateral symmetry of these Ctenophoræ is one of their most characteristic family distinctions. But this symmetry is so peculiar, that, far from exhibiting a transition to the Cestidæ and Calymnidæ or Mnemiidæ, as Gegenbaur believes, it presents the most striking contrast with them. In the Cestidæ, as well as in the Calymnidæ and Beroids proper, the compression is lateral; that is to say, the lateral spheromeres are reduced in comparison to the great development of the anterior and posterior pairs, or, in other words, the cœliac diameter is the longest, and the diacœliac the shortest, of the two transverse diameters: while in the Mertensidæ the compression is diametrically opposite, the lateral spheromeres being greatly developed, while the anterior and posterior pairs are much reduced, so that here the cœliac diameter is much shorter than the diacœliac. Mertens, in his description of Beroe compressa, has already alluded to this difference between the two types, and also noticed another structural peculiarity coinciding with the antero-posterior compression in the form of the circumscribed area, which is short and petaloid, while in the Cydippidæ it is long, with parallel sides. In conformity with this inequality of the spheromeres and the prominence of the anterior and posterior pairs, the abactinal side of the larger spheromeres projects more or less, thus giving a heart-shaped outline to the abactinal pole, on which the circumscribed area is seen in a depression of the short cœliac diameter. A corresponding inequality is observed in the development of the vertical chymiferous tubes and their rows of locomotive flappers. In the Cydippidæ proper, there is hardly a perceptible difference between them: in the Mertensidæ, on the contrary, the lateral pairs are much longer than the anterior and the posterior pair. This again might easily be mistaken for a resemblance between the Mertensidæ and the Mnemiidæ or Calymnidæ, were not the most developed chymiferous tubes and rows of locomotive flappers in the latter those of the anterior and posterior spheromeres, while in the Mertensidæ the most extensive chymiferous tubes and rows of locomotive flappers are those of the lateral spheromeres. The extraordinary development of the parts arranged in the direction of the diacœliac diameter constitutes, in fact, the most striking family character of the Mertensidæ, and determines its peculiar form. In accordance with this preponderance of the sides, it is worthy of remark that the whole tentacular apparatus of the representatives of this family is larger and more complicated than that of any other group of Ctenophoræ, in comparison to the absolute size of these animals. Mertens has mistaken the base of the tentacles for ovaries. To this family belong the genera Mertensia *Less.* (Beroe compressa *Mert.*), Owenia *Köll.*, Gegenbauria *Ag.* (Eschscholtzia cordata *Köll.*), and Martensia *Ag.* (Beroe octoptera *Mert.*).

We have thus three families of the Ctenophoræ Saccatæ: the CALLIANIRIDÆ, the CYDIPPIDÆ proper, and the MERTENSIDÆ, the first of which is still very imperfectly known.

CESTIDÆ. Whether the genus Cestum constitutes a sub-order by itself or not, it is unquestionably the type of a distinct family, for which the names Cestoideæ and Cestidæ have been proposed by Lesson and by Gegenbaur. These names are objectionable so far as they resemble too much that of the Helminths called Cestoidea, and a mere grammatical difference in the termination of a systematic name hardly constitutes a satisfactory distinction. Eschscholtz united Cestum with Cydippe and Callianira; but, leaving the peculiar arrangement of the rows of locomotive flappers out of consideration, the tendency of the Cydippidæ, and especially of the Mertensidæ, to elongate in the direction of the transverse or diacœliac diameter, while in the Cestidæ the prominent diameter is the longitudinal or cœliac diameter, seems to indicate different affinities and a closer relation to the Ctenophoræ Lobatæ. This relation seems further supported by the position and termination of the tentacular apparatus, which trends in the direction of the cœliac cavity, and protrudes on the sides of the actinostome, and not in the direction of the abactinal pole, as in the Cydippidæ and Mertensidæ. It is true, McCrady has noticed that a change in the direction of the tentacular tubes takes place with the growth of Bolina; but this does not militate against the importance of the course of the tentacular apparatus in adult Ctenophoræ, since in all the Lobatæ known it protrudes from the sides of the actinostome in their adult state, and in all the Saccatæ examined with reference to this point its opening is turned towards the abactinal pole. Among the less known species, Cydippe dimidiata *Esch.*, and Beroe glandiformis *Mert.*, are the only ones in which it is represented as trending in the opposite direction. But Grant also represents that of Beroe Pileus as trending in the direction of the mouth, when its real position is certainly the reverse. We may, therefore, well consider the direction of the tentacles as characteristic of the sub-order of the Ctenophoræ Saccatæ and Lobatæ; and, making due allowance for the possibility of mistakes with reference to a structural feature thus far not sufficiently noticed among the characters of these animals, allow it its due weight in the estimation of the affinities of Cestum.

If I am not greatly mistaken, the singular animal described by Gegenbaur as a distinct genus, under the name of Sicyosoma, is a young Cestum; for what he takes to be the ovaries reminds me rather of the remnants of the yolk of an egg. When it is remembered that Cestum is the largest of all the Ctenophoræ, and that therefore its young may be widely different from the adult, and is not likely to resemble the young of other genera, considering the typical peculiarities of Cestum; when it is further remembered that the tentacular apparatus of Sicyosoma trends in the direction of the mouth, as in Cestum,—this supposition will appear more probable than that of Gegenbaur, who regards it as an adult form of a very low organization.

SECTION IV.

THE NATURAL FAMILIES OF THE CTENOPHORÆ LOBATÆ.

Eschscholtz was the first to perceive the affinities which unite these Acalephs into one natural group, to which he gave the name of Beroidæ Lobatæ in the account of his investigations published in the Isis for 1825. Four years later, he changed that name to Mnemiidæ, in his "System der Acalephen;" but, as we have already seen, the Ctenophoræ Lobatæ constitute a natural sub-order, and not simply a family. Lesson, on the other hand, regarding the whole type of Ctenophoræ as one family, subdivided it into eight tribes, three of which, the Leucothoeæ, the Seuroeæ, and the Calymmeæ, belong to the Ctenophoræ Lobatæ, while his Callianiræ embrace Cydippidæ as well as genuine Lobatæ. Gegenbaur unites all these Acalephs into one family, called by him Calymnidæ. It is not difficult, however, to trace different patterns among them. In the first place, I would call attention to the very peculiar form of the genus described by Gegenbaur under the name of Euramphæa. It differs from all other Ctenophoræ by the remarkable prominence of the actinal diameter, which gives this type a very elongated appearance, strikingly contrasting with the prominence of the cœliac diameter in others. Again, the compression of the sides, combined with the sudden dilatation of the anterior and posterior spheromeres into broad lobes projecting from the actinal part of the narrow sides of the body, and the equally prominent projection of the abactinal part of the broad sides of the body, extending sideways much beyond the abactinal pole, give this Acaleph a very unusual appearance, and show it to be the type of a distinct family, for which I propose the name of Euramphæidæ. Besides the genus Euramphæa, I am inclined to refer to it another Acaleph, thus far very imperfectly known, because it was described and figured from a mutilated specimen by Chamisso, and has not been observed since; but the parts preserved agree so fully with Gegenbaur's Euramphæa, that the close affinity of the two can hardly be doubted. I allude to Chamisso's Callianira heteroptera (Nov. Act. Acad. Nat.

Curios. X. Pl. 31, *Fig.* 3), the type of Eschscholtz's genus Hapalia, afterwards called Polyptera by Lesson.[1] Fully to appreciate the peculiarity of the form of the Euramphæidæ, it must be borne in mind that the lobe-like prolongations of their most prominent spheromeres trend in the direction of the cœliac diameter on the actinal side of the body, as in the Mnemiidæ proper, while the appendages on the abactinal side rise as keels from the broad side of the animal and project in the direction of the diacœliac diameter, like the most prominent spheromeres of the Mertensidæ, except that in the family of Euramphæidæ they are still more prominent and assume the shape of elongated horns. In consequence of this arrangement, the appendages of the actinal and those of the abactinal side of the spherosome stand crosswise.

The BOLINIDÆ constitute a second family among the Ctenophoræ Lobatæ, including part of Eschscholtz's Mnemiidæ and of Gegenbaur's Calymnidæ, part of Lesson's tribe of Callianiræ, his Leucothoeæ, and part of his Calymneæ. Lesson's attempt to subdivide the Ctenophoræ into minor groups was a failure, the tribes he adopted being entirely artificial. The characters he assigns to the Callianiræ exist only in a few of them; for neither Mnemia nor Bolina has prominent ribs, the rows of locomotive flappers being nearly on a level with the surface of the spherosome: while Leucothea, which he separates, as a tribe, from Bolina, is closely allied to it; and Chiaja, which he refers to the Callianiræ, is identical with Eucharis multicornis,—and yet Lesson places Eucharis in another tribe. Under such circumstances, the first step we have to take in order to ascertain the general relations of all these Acalephs is to compare them more minutely with one another. I shall, of course, take as my standard the representative of the whole type which I know best,—the Bolina alata of the American coast of the Northern Atlantic. The characteristic form of this Acaleph is determined by the prominence of the anterior and posterior spheromeres over the lateral pairs, and the equable convergence of the eight spheromeres towards the abactinal pole, which gives a rounded form to that side of the spherosome, while the anterior and posterior spheromeres extend beyond the actinal pole, and the shape of two lobes, more or less expanded in different genera, but always closely connected with the actinal region. Upon the sides arise two auricles in the prolongation of the lateral rows of locomotive flappers.

Mnemia norvegica *Sars* and Bolina septentrionalis *Mert.* have exactly the same form, and agree so fully in the details of their structure with Bolina alata, that I

[1] Lesson's name cannot be retained, not only because it is preoccupied, but also because it is of later date than that proposed by Eschscholtz (Isis, 1825, p. 742) for the same Acaleph. In his "System der Acalephen," Eschscholtz does not mention this genus, not even as synonym, but refers the species upon which it was founded to the genus Mnemia as M. Chamissonis.

have no doubt respecting the generic identity of these three species, to which Bolina hibernica *Patters.* must be added, probably as synonyme of Sars's Mnemia norvegica. The form of Bolina elegans *Mert.* does not differ at all from that of Bolina alata, but there are generic differences between them, the course of the chymiferous tubes in the lobes of the tropical Bolina elegans being different from that of the northern Bolina alata and allied species, and the surface papillate, as in Leucothea, Chiaja, and Eucharis. But whether Leucothea[1] formosa *Mert.*, Alcinoe papillosa *Delle Chiaje*, and Eucharis multicornis *Esch.*, belong to this or the next family, I am unable to determine, as the connection of the lobes with the spherosome is not accurately described. Again, Leucothea differs in having a complicated tentacular apparatus, which is simple in Eucharis multicornis. I believe Gegenbaur to be correct in assuming that Eucharis Tiedemanni *Esch.* differs generically from Eucharis multicornis; and that the latter is identical with Alcinoe papillosa, for which Lesson has proposed the generic name of Chiaja, so that Alcinoe papillosa should be called Chiaja multicornis,[2] and the name Eucharis retained for Eucharis Tiedemanni.

Gegenbaur has questioned the validity of the genus Bolina, and believes it to coincide with Mnemia. I believe he is mistaken in that respect. Mnemia has not the form of Bolina, but coincides with Alcinoe *Rang* in the structure of its lobes, which are not simple prolongations of the actinal side of their spheromeres, but rise as lateral folds above the actinal pole of the spherosome, and overlap the lateral spheromeres. On that account, I do not hesitate to consider the genera Alcinoe and Mnemia as belonging to a distinct family, for which the name of MNEMIIDÆ must be retained, and to which the genera LeSueuria and Eucharis proper may also belong. Beroe costata *Reyn.* probably forms another genus of this family. The prolongation of the external row of flappers of the auricles, in the direction of the abactinal pole, along the furrows which separate the lobes of the spherosome from the lateral spheromeres, seems characteristic of this family. I have observed nothing of the kind in Bolinidæ.

I shall retain the name of CALYMMIDÆ, applied by Gegenbaur[3] to the whole sub-

[1] Most writers erroneously call this genus Leucothoe. Mertens gave it the name Leucothea.

[2] As this page came up from the printing-office, I noticed that I had not alluded to a very interesting paper by MILNE-EDWARDS, Note sur l'appareil gastro-vasculaire de quelques Acalèphes Cténophores, published in the Annales des Sciences naturelles, 4e série, vol. 7, p. 285. Owing to the irregularity with which this important periodical has been received at our university library, I did not know of Milne-Edwards's earlier investigations upon the same subject when I published my paper on the Beroid Medusæ in 1850, and had almost missed an opportunity of referring to this later communication, which I shall have to quote frequently hereafter.

[3] Gegenbaur writes Calymnidæ; but, the name being derived from Calymma, should be spelled Calymmidæ.

order of the Ctenophoræ Lobatæ, for a small family, of which the genus Calymma *Esch.* is the type. This family does not correspond to Lesson's tribe Calymmeæ, for under that head Lesson unites some Bolinidæ and some true Mnemiidæ with the genus Calymma. As limited here, the family of Calymmidæ represents a morphological step beyond the Mnemiidæ. We have seen that in the family of Bolinidæ the lobes formed by the actinal prolongation of the anterior and posterior spheromeres are not separated from the spherosome along the lateral spheromeres, but are simply an extension of the actinal portion of their respective spheromeres. In the Mnemiidæ, the separation of the lobes from the spherosome extends in the shape of a furrow along the lateral spheromeres, which the lobes overlap. In the Calymmidæ, judging from the figures of Mertens, the actinal region and the sides of the spherosome are rendered still more independent by the course of the lateral rows of locomotive flappers and the preponderance of the cœliac diameter. Contrary to the disposition of the Bolinidæ, the anterior and posterior rows of locomotive flappers are the shorter ones, and the lateral pairs, instead of trending in the direction of the actinal diameter, run forward and backward and form arches in an antitropic direction at the point where the auricles arise, thus leaving on each side a broad lateral area uncovered, the centre of which is occupied by the cœliac cavity. Besides Calymma, I think that Lesson's genus Bucephalon belongs to this family. Owing to the imperfect illustrations of the genus Axiotima, I am unable to decide whether it also belongs here or with the Bolinidæ.

The family of OCYROIDÆ, Lesson's tribe of Ocyroeæ, constitutes, morphologically considered, the counterpart of the Calymmidæ, as far as I can judge from Rang's illustrations. The actinal region of the spherosome seems entirely free from the anterior and posterior lobes, which, instead of arising from an actinal prolongation of their respective spheromeres, as in the Bolinidæ, are formed by an abactinal development of the anterior and of the posterior spheromeres. Moreover, each lobe is bilobed, indicating clearly that it is formed of two spheromeres, corresponding to the lateral spheromeres and their respective auricles. The lateral rows of locomotive flappers trend in the direction of the cœliac diameter, as in the Calymmidæ, but are very short, in conformity with the actinal projection of the central part of the spherosome, and give rise to auricles, the base of which is nearer the abactinal poles than in any other family. Owing to their bilobed form, the anterior and posterior lobes resemble strikingly the auricles. They are, in fact, the morphological equivalents of the auricles, only much larger, soldered together, and supporting long rows of locomotive flappers; while the auricles of the four lateral spheromeres are free and short. The view which Rang has published of Ocyroe maculata as seen from the abactinal pole is one of the most instructive illustrations extant for the study of the morphology of the Ctenophoræ.

CHAPTER THIRD.

NORTH AMERICAN CTENOPHORÆ.

SECTION I.

THE GENUS PLEUROBRACHIA AND ITS SPECIES.

ALL our knowledge of the animal kingdom being derived from a study of individuals, and our insight into their various relations growing out of the fullest comparisons between them, it is natural, that, in describing animals, we should at times dwell more extensively upon the results of such comparisons, and at other times turn our attention more especially to the conditions under which they live. Investigations neglecting either the one or the other side of the subject must, from the nature of things, remain imperfect. It is only when the study of the structure and functions of an animal draws to a close, and we have made ourselves perfectly familiar with its mode of life, that we may begin a systematic survey of its various connections, and ascertain its position in the system, as determined by its anatomical peculiarities, its embryonic growth, the period of its appearance upon our globe, and its geographical distribution upon its surface. But science cannot take for granted mere results, presented in a dogmatic form: it requires the fullest evidence of every statement and the fullest demonstration of every inference. Special descriptions must therefore be full and minute: they must, moreover, be comparative, and even embrace the widest range of comparisons, that no doubts may remain in the mind of the reader respecting the correctness of the information offered him. I have on that account thought it desirable to reproduce here such parts of the descriptions of the North American Ctenophoræ published in the Memoirs of the American Academy for 1849 as may throw additional light upon the subjects discussed in the preceding chapters. I begin with our Pleurobrachia, a small, rounded, transparent body with two long threads on opposite sides, which may be observed, during the whole summer, along the shores of Massachusetts and Maine, and, further north, to the shores of Greenland.

The Ctenophoræ differ essentially from the Discophoræ. Both their form and organs of locomotion give them a different appearance. The Discophoræ, setting aside the various modifications arising from marked peculiarities of their outline, move like an umbrella, which, by alternately opening and shutting, would make its way under water by means of such movements. It is by the contraction of the body alone, or rather by the agency of the motory cells which form that mass, that motion is produced in these animals. Not so in the Beroid Medusæ, where, besides the action of the motory cells, the whole body, more or less spherical or ovate, compact or split at one end, is kept swimming by the flapping of innumerable small paddles arranged in vertical rows, like the ribs of an orange, upon the outer surface. These rows are generally eight in number, extending from one pole of their spheroid body to the opposite, like the meridians of an artificial globe. But, owing to the inequalities in the motions of their vertical flappers, and their radiated arrangement upon the more or less spherical body, these animals have a somewhat rotatory motion, unless the paddles move on all sides with perfect steadiness and uniformity.

There can be scarcely any thing more beautiful to behold than such a living transparent sphere sailing through the water, coursing one way or another, now slowly revolving upon itself, then assuming a straight course, or retrograding, advancing, or moving sideways, in all directions with equal precision and rapidity; then stopping to pause, and remaining for a time almost immovable, a slight waving of some of its vibrating organs easily counterbalancing the difference of its specific gravity and that of the water in which it lives. So Pleurobrachia may appear at times, and so does it also appear when moving in a state of contraction. But generally, when active, it hangs out a pair of most remarkable appendages, the structure and length and contractility of which are equally surprising, and exceed in wonderful adaptation all I have ever known among animal structures. Two apparently simple, irregular, and unequal threads hang out from opposite sides of the sphere. Presently these appendages may elongate, and equal in length the diameter of the sphere, or surpass it, and increase to two, three, five, ten, and twenty times the diameter of the body, and more and more; so much so that it would seem as if these threads had the power of endless extension and development. But as they lengthen they appear more complicated: from one of their sides other delicate threads shoot out like fringes, forming a row of beards like those of the most elegant ostrich feather, and each of these threads itself elongates till it equals in length the diameter of the whole body, and bends in the most graceful curves. These two long streamers, stretching out in straight or undulating lines, sometimes parallel, then diverging or variously curving, follow the motions of the main sphere, being carried on with it in all its movements, which are no doubt influenced by them to a considerable extent. Upon considering this wonderful being, one is at a loss which most to admire, the elegance and complication of that structure, or the delicacy of the colors and hues, which, with the freshness of the morning dew upon the rose, shine from its whole surface. Like a planet round its sun, or, more exactly, like the comet with its magic tail, our little animal moves in its element as those larger bodies revolve in space, but unlike them and to our admiration, it moves freely in all directions; and nothing can be more attractive than to watch such a little living comet as it darts with its tail in undetermined ways and revolves upon itself, unfolding and bending its appendages with equal ease and elegance, at times allowing them to float for their whole length, at times shortening them in quick contractions and causing them to disappear suddenly, then dropping them as it were from its surface so that they seem to fall entirely away, till, lengthened to the utmost, they again follow in the direction of the body to which they are attached, and with which the connection that regulates their movements seems as mysterious as the changes are extraordinary and unexpected. For hours and hours I have sat before them and watched their movements, and have never been tired of admiring their graceful undulations. And though I have found contractile fibres in these thin threads, showing that these movements are of a muscular nature, it is still a unique fact in the organization of animal bodies, that parts may be elongated and contracted to such extraordinary and extensive limits by means of muscular action. And what is so surprising, is not so much the sudden and powerful contraction which brings within the compact limits of a pin's head the whole mass of these tentacles that a moment before were floating so elegantly through such a great extent in the water, as the relaxation, which takes place in an absolutely passive manner; for when watching them we are suddenly struck with astonishment on finding that the tentacle which we expected to see drop to the bottom of the jar is still in organic connection with the body from which it hangs. Plate I. of my paper in the Memoirs of the American Academy represents some few of the attitudes of our Pleurobrachia in its various movements, one of which is reproduced in this work (Pl. II^a. *Fig.* 25); but I cannot find words to describe all the beautiful changes which the parts thus in motion assume in different attitudes. At one moment the threads, when contracted, seem nodose; next, when more elongated, these knots are stretched into the appearance of a spiral; next, the spiral, elongating, assumes the appearance of a straight or waving line. But it is especially in the successive appearances of the lateral fringes arising from the main thread that the most extraordinary diversity is displayed. Not only are they stretched under all possible angles from the main stem, at times seeming perpendicular to it, or bent more or less in the same direction, and again as if combed into one mass; but a moment afterwards every thread seems to be curled or waving, the main thread being straight or undulating; then the shorter threads will be stretched straight for some distance and then suddenly bent at various angles upon themselves, and perhaps repeat such zigzags several times, or they may be stretched in one direction and bent at various angles in the plane of another direction; then they may be coiled up from the tip and remain hanging like pearls suspended by a delicate thread to the main stem, or like a broken whip be bent in an acute angle upon themselves with as stiff an appearance as if the whole were made up of wires; and, to complete the wonder, a part of the length of the main thread will assume one appearance and another part another, and pass from one into the other in the quickest possible succession: so that I can truly say, I have not known in the animal kingdom an organism exhibiting more sudden changes and presenting more diversified and beautiful images, the action meanwhile being produced in such a way as hardly to be understood. For, when expanded, these threads resemble rather a delicate fabric spun with the finest spider's thread, at times brought close together, combed in one direction without entangling, next stretched apart, and preserving in this evolution the most perfect parallelism among themselves, and at no time and under no circumstances confusing the fringes of the two threads: they may cross each other, they may be apparently entangled throughout their length, but let the animal suddenly contract, and all these innumerable interwoven fringes unfold, contract, and disappear, reduced as it were to one little drop of most elastic india-rubber. Week after week I have preserved these animals alive, and have never been tired of comparing again and again their changes in these thousand-fold developments of their appendages. I have called together those who felt the slightest curiosity for such objects to witness these phenomena, and have found them all interested to the utmost; and if I have any thing to regret, it is not the time lost in this contemplation,— for the more I became familiar with the sight, the more was I impressed with its beauty, as I could contrast with the new forms presenting themselves before my eyes those different states with which I had been familiar before, — but the circumstance that the time was too short to trace such a connection between all the microscopic details of their structure and their functions, as would fully explain the latter; although I am aware that I have noticed many particulars which had not been observed before.

The chief difficulty in the comparative study of the different genera of this family arises from the circumstance, that they move permanently in different directions, some having the mouth naturally turned upward and others downward; and that, from not having perceived this difference, the parts placed in opposite positions have been identified with each other by different writers in different genera, and therefore require a complete revision.

The type under consideration, for which I retain the name of Pleurobrachia as the most ancient applied to species of this particular conformation, is one of those which are deprived of peripheric lobes, that is to say, in which the gelatinous body is undivided, and the mouth constantly turned upward or forward when in motion; while the genus Bolina, to which I shall next call attention, is one of those in which one extremity of the sphere is split into two lobes, between which the mouth is situated, and in which this opening is almost constantly turned downward when the animal is moving, though sometimes, when the animal is at rest, it turns in the opposite direction, opening widely its two lobes. It will be obvious how great mistakes may arise from comparing two animals constructed upon the same plan, but kept in a reversed position when contrasted. Unhappily, all these animals have been figured without reference to the normal position in which they should be compared, and, no allusion to these prominent differences being made, it is hardly possible to reconcile the descriptions of one author with those of another.

The genus Pleurobrachia is limited to those species of Cydippidæ in which the body is nearly spherical or slightly elongated, and slightly compressed laterally; the locomotive flappers extending from near the margin of the mouth all round the sphere, in eight vertical rows, towards the opposite centre, where they approach much closer to each other than on the side of the mouth. The tentacular sacs are wide and arched sideways, their bottom rising toward the actinal pole, while the aperture is turned towards the abactinal side of the spherosome, and opens in the interambulacral space between the lateral pairs of spheromeres. Pleurobrachia differs from Eschscholtzia chiefly in the development of the rows of locomotive flappers, which, in the latter genus, do not extend beyond half or two thirds of the whole height. This is also the case with Dryodora (Gegenbaur's Mertensia, and Mertens's Beroe glandiformis); but Dryodora has simple tentacles, while they bear lateral threads of a uniform structure in Eschscholtzia and Pleurobrachia, and two kinds of appendages in Hormiphora (Cydippe hormiphora, *Gegenb.*). Janira is chiefly characterized by the prominence of the actinal diameter.

I know at present only three species of this genus sufficiently well to characterize them as distinct species:[1] one is the common *Pleurobrachia* of the shores

[1] After defining the natural limits of the genus Pleurobrachia in accordance with its structural peculiarities, it would be desirable to enter into a critical comparison of its species; but this is impossible, owing to the imperfection of the illustrations relating to them. All I am able to do is to point out those I believe to belong here. About Pleurobrachia Pileus *Flem.* there can be no doubt: it is the common species of the German Ocean, with which Cydippe Pileus *Esch.* is identical. Judging

of Europe; the second, which I have named *Pleurobrachia rhododactyla*, occurs on the eastern shores of the northern United States; and the third was recently observed on the north-west coast of America by my son, Alexander Agassiz.

Though, at first sight, our Pleurobrachia appears spherical, it is slightly compressed in a direction at right angles with the base of the tentacles; so that the cœliac diameter is really shorter than the diacœliac. As it is of great importance

from the range of differences observed among individuals of different ages of the species I have described as Pl. rhododactyla, I hold that the two species described by Forbes and Patterson are one and the same with Pl. Pileus, the rows of locomotive flappers being comparatively broader, and the number of flappers less, in young than in old specimens, and the tentacles, having generally not yet sustained any injuries, are longer and more active. I therefore consider Cydippe Flemingii *Forb.*, Cydippe pomiformis *Patters.*, Beroe ovatus *Flem.*, and even Cydippe Infundibulum *Esch.* (Beroe Mülleri *Less.*), as synonymes of Pleurobrachia or Cydippe Pileus. Whether the Mediterranean representative of this genus, described as Cydippe densa *Esch.*, to which Beroe Pileus *Risso* and Beroe albens *Forsk.* also belong, is identical with the northern Pl. Pileus, or not, I have no means of ascertaining; the red tentacles seem to indicate a specific difference, and the circumstance that this species has thus far only been noticed in the Lusitanic fauna, while Pl. Pileus belongs to the Celtic fauna, would justify this inference. The Beroe Pileus of Fabricius (which must not be confounded with Cydippe Cucullus, as was done by Eschscholtz) is very likely the North American Pl. rhododactyla. This Beroe Cucullus, erroneously called Cydippe Cucumis by Lesson, is a Mertensia, identical with the Beroe Pileus of Scoresby (Mertensia Scoresby *Less.*), and also identical with Beroe ovum *Fabr.* (Cydippe ovum *Esch.*). Lesson has made another mistake in referring Cydippe bicolor *Sars* to his Cydippe Cucumis. Sars's species is a genuine Pleurobrachia, distinct from Pl. Pileus, but closely allied to our Pl. rhododactyla. It is, in fact, the European representative of the Pl. rhododactyla, and, like this, belongs to the boreal fauna; while Mertensia Scoresbyi, which should be called M. Cucullus, is an arctic species. Pl. Bachei, discovered by my son on the shores of Washington Territory, is another species with red tentacles, but differs from Pl. rhododactyla in having a longer funnel, a shorter cœliac cavity, and the actinal part of the tentacular sac also shorter. Pl. bicolor, judging from Sars's description, has white lateral threads, the tentacle itself being alone red. To these species must be added Beroe Basteri *Less.* from the coast of Peru, Beroe rosens *Q.* and *G.* from the straits of Timor, and Beroe Santonum *Less.*, which is probably identical with Pl. Pileus. Lesson refers these three species to the true Beroids, but they unquestionably belong to the genus Pleurobrachia: the tentacles must have been overlooked. No true Beroid ever has the form of these Acalephs. The genus Janira, which comes nearest to Pleurobrachia, embraces, as far as I know, only the following three species: Cydippe elliptica *Esch.*, Beroe Cucumis *Mert.*, and Beroe elongatus *Q.* and *G.* Janira hexagona is a Callianira, and Janira octoptera a Martensia, well to distinguish from Mertensia, though both belong to the family Mertensidæ. To Eschscholtzia I refer only Cydippe dimidiata *Esch.*; Eschscholtzia glandiformis *Less.* is the type of the genus Dryodora (Mertensia Gegenb.); while Eschscholtzia cordata is the type of the genus Gegenbauria *Ag.*, and belongs to the family of Mertensidæ. Cydippe hormiphora is also the type of a distinct genus, for which I would propose the name Hormiphora: it is closely allied to Eschscholtzia and Pleurobrachia, and belongs with them to the family of Cydippidæ proper. Cydippe brevicostata *Will.* and Cydippe quadricostata *Sars* are very likely young Ctenophoræ Lobatæ, according to the observations of McCrady.

to the full understanding of the internal structure of this animal and the correct appreciation of all its organs to form a correct idea of their respective position, I feel compelled to enter into some tedious details respecting this slight variation from the spherical form; for, though scarcely appreciable, it has a direct bearing upon the connection of all the organs, which, upon close examination, are found to preserve, throughout the order of Ctenophoræ, a constant relation to this apparently insignificant difference between the three diameters of the body,—so much so that these globular animals are as truly bilateral in the arrangement of all their parts, as any other species of the whole group.

The mouth opens transversely; and there is upon the opposite pole of the sphere an oblong, narrow, circumscribed area, placed also in the same direction, transversely to the greater diameter. The two tentacles with their fusiform sockets are placed at right angles with the transverse split of the mouth and the opposite oblong area, the tentacles being in the diacœliac diameter, the mouth and the area in the cœliac diameter, and the main axis of the digestive cavity trending vertically between them. The rows of locomotive flappers alternate, two and two, with these four radiating directions. So that there are four rows on one side of the plane passing through the tentacles, and four on the other; and also four on one side of the plane passing through the mouth and the opposite area, and four on the other,—no one being placed either in the prolongation of the mouth or in that of the bases of the tentacles (Pl. II^a. *Figs.* 20, 21, 22, and 23).

Owing to the compression of the body, and the difference in the curvature of its actinal and abactinal sides, the eight rows of locomotive flappers have their upper and lower halves bending in a somewhat different manner. Again, two pairs, perfectly equal, inclosing the base of the tentacles, stand in antitropic relation to one another along the prominent side; while two other pairs, inclosing the prolongation of the angles of the mouth and the circumscribed area at the opposite pole, extend in a similar manner along the flattened side. The consequence of this arrangement is, that each side of the body has two equal rows of locomotive fringes placed in a symmetrical manner opposite each other from side to side and crosswise, those of opposite sides being identical, but differing from those which stand at right angles with them.

Having thus ascertained that the body of this animal is neither vertically nor transversely circular, and that there is a medial axis with reference to which the arrangement of all the parts is regulated, the question at once arises how we should consider these diameters: whether the mouth should be placed upward or downward, or whether it should be considered as the anterior extremity, and what are the relations of the sides. As with the other Medusæ, whatever view we take of the subject, when we compare these animals with either Polypi or

Echinoderms to ascertain their homologies, we must, as a matter of necessity, bring them all into the same respective position, and contrast the arrangement of their parts in their mutual correspondence. There is, however, no difficulty about their identification, inasmuch as the mouth is made in every case the central point of comparison. It has been already ascertained, that Polypi, though truly radiated animals, have, in most of their types, if not in all, a rudimentary indication of a longitudinal axis in the oblong form of their mouth, which is the first indication of a bilateral symmetry in the animal kingdom, occurring even among the lowest Radiata; while in Echinoderms it rises higher and higher, and becomes so prominent in the Spatangoids as to influence not only the general form, but even the number and arrangement of the internal parts, and the length and special development of the external appendages and of the ambulacral rows.

The class of Acalephæ, which is intermediate between those of Polypi and Echinoderms, holds in these respects also an intermediate position. In Ctenophoræ, we have a slightly compressed body and an oblong mouth. But the mouth may open in a direction transverse to the elongation of the body. The question therefore is, Does the mouth, with the plane which passes through it and the opposite area, in this case indicate the length of the axis of the body, and divide it into a right and a left half; and are therefore the tentacles lateral appendages, one on the right side and the other on the left side, as we should consider them if we were to place the axis of the mouth in the same direction as the axis of the mouth in Polypi? or have we to consider the tentacles as arranged along the longitudinal axis, one on the anterior, and the other on the posterior, extremity? And in that case, are the folds of the mouth rather the first indications of an upper and a lower lip, — as we should consider them were we to compare the transverse position of the mouth with the position this opening assumes in the oblong symmetrical Echinoderms, in which the bilateral symmetry has been made prominent, — or have we to view also the indication of bilateral symmetry among Polypi as a tendency to such an arrangement of the two lips? I think I can be positive in the case of Polypi; for in Actinia, as well as in Astrangia and many other Actinoid Polyps, the oblong fold of the mouth has unequal angles; and it would be to suppose the right and left angles of the mouth to be assymetrical, and the upper and the lower lip to be identical, if we should not consider this split as running in the longitudinal axis. And that it indicates really a longitudinal axis is shown by the circumstance, that fecal matters are discharged along the rounded angle of the oblong mouth, opposite to which there is, in many Polypi, a tentacle of a peculiar form, and sometimes differing in color from the others.

This being the case, are there reasons to view Pleurobrachia in a different light? Are the Ctenophoræ more nearly related to Echinoderms in their arrangement than to Polypi? I hardly believe it; for, as the mouth is transverse in many Echini, so also do their anterior and posterior extremities differ more and more, in the same proportion that the bilateral symmetry is increased and made more prominent. It seems to me, therefore, more natural to compare Pleurobrachia with the other Radiata in a position in which the split of the mouth will indicate the antero-posterior diameter, even though the diameter considered as the transverse be thus greater than the longitudinal. This, however, is not the only instance of such a disposition in the animal kingdom. In many Mollusca of the class of Acephala, in the family of Cardiacea, we have numbers of genera and species in which the longitudinal axis is shorter than the transverse. Though the vertical chymiferous tubes with their rows of locomotive fringes are homologous with the ambulacra of Echinoderms, I hold that the position I assign to the Ctenophoræ is in perfect accordance with the general progress of symmetry among Radiata; for the anterior position of the mouth in the Spatangoids does not interfere with its being the centre of radiation, as in all other Echinoderms. The first tendency, beyond a perfectly radiated arrangement, which is introduced among the Radiates, is to a symmetrical disposition and parity between right and left, when the anterior and posterior extremities may be marked by this lateral symmetry only, and not made to differ from each other. Next, the two ends of the antero-posterior diameter are made to differ; and this we see introduced among the higher Echinoderms only. For, though bilateral symmetry can be recognized among Star-fishes and Echini proper, their anterior row does not yet differ from the others; and the first appearance of such a difference is introduced in the Clypeastoids, and more developed in the Spatangoids. If, therefore, the Echinoderms, which as a whole rank above Medusæ, still retain so completely the radiated type, and the bilateral symmetry is developed in them, among so many of their types, solely in their perfect symmetry of right and left, without a difference between forward and backward, why should we expect this in the class of Acalephæ, especially when we are able so easily to refer this type to that of Polypi? I assume therefore decidedly, that the diameter which corresponds to the split of the mouth indicates the longitudinal axis, and shall, in the following pages, describe all parts with reference to this view. I thus consider the halves of the body which would be divided by a plane passing through the split of the mouth and through the opposite oblong area as the right and left halves of this animal, and therefore the tentacles as being placed right and left. But I must for the present leave it doubtful which is right and which is left; for the sides are so completely identical, the two angles of the mouth so absolutely equal, and the prominent projections of the opposite area so uniform, as to afford no indication upon this point. This is a very remarkable circumstance to occur in a class intermediate between two others, in which, notwithstanding their radiated arrangement, the anterior and posterior sides can be fully ascertained. But there may be a compensation for this identity of the anterior and posterior sides in the prominence of the lateral parts of the body.

The parts already mentioned in a general way are not the only ones which have reference to the bilateral arrangement. The tentacles also arise on opposite sides, in two sacs extending inward in an obliquely vertical direction, and reaching a point about as far from the actinal pole as the point from which the tentacles issue is from the abactinal pole. These sacs stand in the interambulacral space between the lateral rows of flappers, with their proximal surface near the fork of the main trunks of the chymiferous tubes,[1] which also branch in opposite directions in the transverse diameter of the body. The disposition of this complicated system is, therefore, also bilateral: two main trunks penetrating symmetrically right and left from the funnel, and branching in such a manner as to reach on each side, with four arms, the four vertical rows of locomotive flappers, and giving on each side also two branches to the base of the tentacles.[2] The chymiferous cavity is full of fluid, which is in constant movement by the agency of vibratory cilia, and also under the influence of a regular pulsation of the whole system in the two halves of the body, so alternating in their contraction and dilatation, that at one time the fluid moves to a considerable extent from one side to the other, and next returns by the contraction of the opposite side through the same tubes in the opposite direction, presenting something similar to what exists in Salpa under different combinations. There is really a regular circulation through the large axial

[1] To facilitate comparisons with the paper of Milne-Edwards on the gastro-vascular apparatus of the Ctenophoræ, I would remark, that he calls *ventricule chylifère* the axial chymiferous cavity, which I have called *funnel; troncs périgastriques supérieurs*, what I have called *main trunks and forks* of the chymiferous system; *vaisseaux costaux*, what I have called *ambulacral tubes; vaisseau périgastrique inférieur superficiel*, what I have called *interambulacral* or *tentacular tube; vaisseau périgastrique inférieur profond*, what I have called *stomachal* or *cœliac tube*. I would also take this opportunity to state, that the description of the chymiferous system of Cestum, published by Milne-Edwards, has convinced me that this genus really constitutes a distinct sub-order, as I suspected; for the course of the lateral ambulacral tubes is quite peculiar, and they are destitute of locomotive flappers. Milne-Edwards is explicit upon that point. I am, however, still inclined to question the absence of cœline tubes, which exist in all the Ctenophoræ I have examined, and I have seen as many as seven species of this order: the figures of Milne-Edwards are drawn in a position in which the cœliac tubes would be covered by the interambulacral tubes, and might therefore be overlooked. Neither Eschscholtz nor Mertens represents cœliac tubes in the species of Cestum which he has described.

[2] There are certainly two parallel interambulacral tubes to each tentacular apparatus, as I have represented them in the Memoirs of the American Academy, Pl. III. *Fig.* 8; and Milne-Edwards must be mistaken in representing only one. In a view like that published by him only one tube is visible; but, facing the trend of the tentacular sockets, both tubes are brought into sight.

cavity; for the main trunks of the chymiferous tubes, with their forks branching in a very symmetrical way in the right and left parts of the body, undergo a rhythmic movement of contraction and dilatation, alternating between the two sides. In those Ctenophoræ which have an oral chymiferous tube communicating with the recurrent branches of the ambulacral tubes, the bilateral circulation is not so prominent. The axial cavity, which I have called funnel, is not to be mistaken for the digestive cavity, though it extends in the same axis with it, in the direction of the abactinal pole; nor is the digestive cavity entirely surrounded by the chymiferous system, as I had supposed when I published my paper in the Memoirs of the American Academy, but only flanked on each side by so wide a cœliac tube as readily to appear like a sac surrounding the whole digestive cavity.[1] The funnel has two apertures, by which it communicates with the surrounding water, and through which it discharges the refuse chyme. These apertures are placed in a symmetrical position on the two sides of the oblong area, opposite the mouth and near its centre, obliquely opposite each other; so that one is in the anterior half upon one side of the body, the other in the posterior half upon the other side. These openings are generally shut; but they open at intervals to discharge the fecal matters, and are afterwards instantaneously shut again. It is very difficult to catch these movements; and even after I had seen them open and shut, I have frequently watched for days without observing a repetition of the operation, which I have, however, seen so many times now, that I entertain no doubt respecting the position of these openings and their natural function. Moreover, balls of fecal matters may almost constantly be seen floating with a rotating motion below these apertures.

This sketch gives as yet but a slight, very incomplete, and superficial idea of the remarkable complication of structure which may be observed in these animals; but such a preliminary illustration was necessary before undertaking a minute description of all parts and their natural relations. And, before alluding to these details, I would request the reader to bear the following points in mind: that Pleurobrachia is not strictly spherical, nor even strictly circular, in any direction; that there is a longitudinal axis, which passes through the mouth and the area opposite; that the tentacles are in the transverse axis, at right angles with the fissure of the mouth; that the digestive cavity trends in the vertical and in the longitudinal axis; that the chymiferous system branches symmetrically in the right and left halves of the body, eight branches reaching the eight vertical rows of

[1] Milne-Edwards has made the same mistake in representing the chymiferous cavity as surrounding the sac into which the mouth leads. Comp. Ann. Sc. Nat. 4e sér. vol. 7, Pl. XVI. *Fig.* 2. The cœliac tubes occupy only the more deeply colored part of his drawing, on the sides of the digestive cavity.

locomotive flappers, two other branches the sacs from which the tentacles issue, and two others following the walls of the digestive cavity, — the four latter arising from the main lateral trunks in the trend of the transverse diameter, while the forks which supply the locomotive flappers trend at first in the direction of the longitudinal diameter, and emit each another fork parallel to the transverse diameter, so that all parts have a precise geometrical relation to each other; and, finally, that the right half of this system alternates in its contractions with the left half.

In the special investigation of the minute structure of the different systems of organs developed in these animals, it will be better to proceed in the order which will assist us in the understanding of all the other systems, rather than to follow a physiological principle.

Though the form is apparently well determined and regular, even superficial investigation will satisfy the observer that it is constantly changing within more extensive limits than might be at first suspected. In the first place, the apparently spherical form is not only frequently altered into an ovate by the vertical elongation of the mass, but it even assumes at times a form rather cylindrical than ovate, especially on the side of the mouth, by the extensive dilatation of this opening. The changes which the mouth assumes in its outlines are very extensive and frequent. When completely shut, it disappears almost entirely; and its position is scarcely marked by any thing more than an indistinct outline, towards which the actinal ends of the rows of locomotive flappers converge. When half-way open or while opening, it assumes an oval form, like a fissure, across the body, which becomes gradually more and more elongated, then widens, and finally expands into an ample, circular, funnel-shaped depression. These movements are rather slow, and may be compared to the undulations of a slug or snail adapting its mouth to the form of its food. The changes in Pleurobrachia, however, do not seem to be called forth by the approach of food, but are rather the result of a natural disposition in this animal to be in an attitude ready to seize upon its prey. Various aspects of the mouth are represented in my former paper.

The whole bulk of the body of Pleurobrachia, excepting the spaces occupied by the digestive and the chymiferous system and the tentacular sockets, is a solid mass of closely packed cells, most of which are of enormous size (Pl. II[a]. *Fig.* 24). Such is the extreme transparency of these cells, that it is very difficult to follow their contour except in profile, and on this account the thickness of their walls has been mistaken for long and slender muscular fibres; and this illusion is oftentimes heightened when the wall wrinkles (*Fig.* 24, *b*, *c*) during contraction, and appears like shrunken fibres. But there is no muscular system apart from the constituent cells of the body, and therefore no contractile fibres of any kind so grouped as to appear to be specially fitted for the movement of any particular organ. Yet the cellular system is not a confused mass, as perhaps might be inferred from the foregoing remarks, but these gigantic vesicles, reminding one of the fusiform pulp-sacs of the orange both by their shape and disposition, have a most beautiful and extraordinary arrangement, which is thus far only known among Ctenophoræ.

In order that there may be no misapprehension in regard to the nature of this extensive motory system, it is advisable to render its cellular character as distinct as possible in the mind of the reader, and therefore, before proceeding further, we will describe the cells in detail. We have already remarked on their extreme transparency: this, combined with their great length and the prominence of their walls, in profile, conspires to obscure their true character, and suggests the idea, even to the observer well acquainted with them, that they are a network of widely separated fibres; and as such they have been described in a previous memoir,[1] though their vesicular character was already observed to some extent. They are in reality elongate, irregularly spindle-shaped vesicles (*Fig.* 24), either with blunt ends (*a*) or with all degrees of acuteness to quite slender, pointed terminations (*c*). When seen from either the actinal or the abactinal pole of the body, they generally display a broader outline than from any other point; and, as the eye passes along the sides towards the middle region of the body, they present successively narrower and narrower boundaries, until, at a right angle with the first point of view, they show a minimum of breadth. Viewed transversely, they are irregularly polygonal, and on that account each cell appears to have three, four, or five narrow ribs, trending parallelwise to its longer axis, and corresponding to its angles. When in a state of contraction, the walls are wrinkled transversely to the longer axis (*Fig.* 24 *b c*); but, owing to their transparency, the angles alone are readily seen, and they appear like thin, tortuous fibres, or oftentimes, strange to say, as if they were spiral springs, adapted to keep the body in a state of tension. This false appearance is not easily dispelled if it impresses the mind at the first view of these cells, especially as it is very difficult to trace the true relations of their sides and angles, without having some sort of hint as to their true nature. The total absence of the usual cell constituents — mesoblast and more or less granular contents — contributes also to keep up the illusion; for every thing within is as clear and homogeneous to the eye as blank space itself. Indeed, any one, after remarking the glass-like transparency of these animals, would be apt to doubt whether any structure could be detected in them. Such is the almost ethereal nature of the motive power which governs the actions of Pleurobrachia.

[1] Contributions to the Natural History of the Acalephæ of North America, by L. Agassiz, Mem. American Academy of Arts and Sciences, Boston, Mass., vol. 4, part 2, 1850, p. 330.

The adaptation of means to an end is nowhere in the animal kingdom more beautifully and plainly displayed than in the mode of disposition of the simple material which constitutes, at the same time, the mass and the moving power of this animal: a specialization by arrangement, without a segregation, as a distinct system apart from the other organs. If the greater part of the body of certain Mollusca is subservient to muscular action, how much more extensively does this obtain in the Ctenophoræ.

Viewing the body of Pleurobrachia from the actinal pole (*Fig.* 21 *a*), the whole mass appears, at first sight, to be composed of an aggregation of cells (m m^2), which radiate in every direction from the centre to the periphery, as if an exemplification of the radiate type to which this animal belongs. It is true, these cells are arranged as we have here described; they do not, however, occupy the whole of the space through which they project, but are intimately interwoven with the cells of another system (p p^2), diverging from the tentacular sockets (j) to the periphery. The radiating system, however, is the most extensive, and pervades almost every region of the body: in fact, the only portions which it does not occupy are a small space lying in a direct course between the tentacular sockets and the periphery, and also a thin layer of the periphery, which is exclusively devoted to the system of cells (n n^1) which traverse the spaces between and under the locomotive flappers. In all these systems the longer axes of the component cells trend in the lines of radiation of each system to which they belong: in fact, it is their longitudinal outline which gives the characteristic fibre-like appearance to the mass of the body. This will suffice to give an idea of the general disposition of these cells, and of their relation to each other; but each system needs a much fuller treatment by itself, in order to elucidate its share of influence upon the movements of the body.

For the sake of convenience, we will describe the peripheric system first. It will be seen by the figures drawn from the actinal and abactinal poles (*Figs.* 20 and 21), that the outline of the body is waved or slightly lobed, the lobes corresponding to the spaces between the rows of locomotive flappers (l^1 l^2), so that there may be said to be eight broad ribs alternating with as many narrow and shallow furrows, extending like meridians from the actinal to the abactinal areas. The proportionate breadth of the ribs may be ascertained by inspecting the figures, and they are described more fully in another place. Now, the peripheric cellulo-motory system is divided into two sets of layers, the one corresponding to the broad ribs and the other to the shallow furrows. The first system (n n^1) is by far the most extensive, both in breadth and depth. The surface of each broad rib is at the same time the outer convex surface (*Fig.* 21 n) of a broad band of transversely trending cells; and the inner face (n^1) of each band has the same degree of curvature as the outer surface. Thus every layer of the *interambulacral system* is doubly convex, and therefore thickest along the median line of the lobe, and thins out nearly to an edge, on each side, where it meets the ambulacral layer. It also thins out at the actinal and abactinal ends, and finally terminates (*Fig.* 23 n^3 n^5) on a line with the ends of the rows of locomotive flappers. The longer axes of the cells of this system trend more or less parallel with the surface of each band (*Fig.* 21 n n^1) to which they severally belong, and directly across from one ambulacral row to another (*Fig.* 23 n^3 n^5). Therefore, when they contract longitudinally they tend to draw the rows of locomotive flappers closer to each other, and consequently decrease the peripheric extent of the spherosome. This, we shall see hereafter, has an important bearing upon the peristaltic movements of the body.

A band of similar cells (*Fig.* 21 m^1) — the *oral system* — encircles the mouth, the longer cells trending parallel to the edge of the lips, so that, when the mouth is open and rounded, they are parallel also to the longer axes of those which constitute the interambulacral system. In fact, the boundaries of the two systems — the oral and the interambulacral — merge one into the other, at least at the corners of the mouth, but more faintly at right angles to these points.

The *ambulacral system* consists of bands of cells (*Fig.* 26 x^1 x^2 x^3), which are identical in their nature with those of the interambulacral layers, and are eight in number, one of each underlying a row of flappers (u). The thickness of a band is equal to the distance between the ambulacral tube (r) and the surface of the body, and its lateral expanse corresponds to the breadth of the row of flappers which it underlies; although it cannot be said whether this system belongs exclusively to the locomotive apparatus, or takes part in the peristaltic movements of the body in common with the interambulacral system into which it so gradually passes. The latter agency most unquestionably obtains in the area about the mouth and on the opposite pole, where the different peripheric systems merge into each other, and where neither the ambulacral tubes nor the flappers are present: but in the ambulacral region, the specialization of these cells, for the purpose of locomotion, no doubt, is predominant; and, perhaps, as we shall presently see, some of them are exclusively devoted to the flappers. This assertion will appear to be true upon inspecting *Fig.* 26, in the region (w^1) from which the flappers (u) arise. The ridge (w) upon which each flapper is based is a simple projection from the surface of the body; but its cellular constituents (w^1) are arranged in a peculiar manner, which indicates, as we think, the particular and exclusive use to which they are appointed. The longer axes of these cells each and all trend outwardly in the direction of the base of the flapper; and, unless we misinterpret appearances, they may be recognized in the flapper itself, where their outlines appear as longitudinal striæ. In plain terms, we would say that it is our conviction that these cells are arranged parallelly in the flapper, and that their outer free ends constitute the marginal fringe of this organ, and furthermore that each cell is as it were a single tooth in the comb-like flapper, reaching in one stretch from the base to the margin. Thus the locomotive flappers would be formed by the simple projection of these cellulo-motory vesicles beyond the surface of the body,[1] and by their arrangement in a single row, combined with lateral coalescence. As these cells are simple prolongations from the midst of other similar cells, we should take it for granted that they have similar motive powers; for no action of special muscles — supposing that they were present, which is not true — could be so transmitted from the base along the flapper as to give it that peculiar curve which it frequently assumes when in a stationary condition: but any one may understand how the cells themselves can assume such a curve, and that each combined row of cells moves by the inherent power of its components, for, as we have frequently observed, when the flappers are minutely split up from edge to base, each cell vibrates isolatedly, and either in consonance with the others or at random.

It has oftentimes been noticed by observers, that whilst Pleurobrachia is in a dying state and even falling to pieces, and the epithelial cells peel off from the body, and, as we have observed, from the flappers too, in the form of a filmy mucus, the flappers themselves remain to the last moment flapping convulsively, wherever there is a bit of the body to which they may adhere, thus showing their intimate connection with the deeper seated cells. The ganglion-like bodies described in my former paper on Beroid Medusæ are nothing but the points of convergence of several such cells: they are very irregular in shape, and not always to be seen.

The remarkable iridescence of the flappers, we think, can be easily explained by reference to what we now know of their intricate structure. Each cell being excessively flattened, the walls are approximated like superposed laminæ, and these, with the surfaces of the epithelial cells, form all that is required to produce the same kind of action upon light as a pile of thin plates of mica or glass.

The tentacular sockets (*Fig.* 15 j j^1) are embraced by a wall whose cellular constituents closely resemble those of the interambulacral system; and, in fact, as will be shown hereafter in detail, these sockets are nothing more nor less than deep depressions in the latter system: the cells trend in the same general direction, that is, their longer axes trend transversely to the length of the sockets, and, for nearly one half of their distal extent, from the base of the tentacles (g) to the aperture (j^1), completely encircle them, like a constrictor muscle. At the basal half of the sockets, these cells form only a semicircle (*Fig.* 15 j j^2, *Fig.* 21 n^6) on

[1] This being true, the locomotive fringes are in no way comparable to vibratile cilia, as I had supposed before I knew fully their structure, and as Will also admitted.

the peripheric side; but the wall is continuous with the outer wall (page 235, *Fig.* 87 $\beta' \ \beta''$) of the tentacular apparatus, and thus the circle is completed.

The next system that demands our consideration is the largest of all; and we may call it the *radial system*, from the fact that it radiates equally on all sides, from the digestive cavity and the axial funnel to the peripheric systems. When seen from the actinal (*Fig.* 21) or abactinal pole, the cells seem to radiate in direct lines from an imaginary centre; but in a profile view (*Fig.* 23), the true course of these bodies ($m^2 \ t \ t^1$) is discovered to be in two oblique directions, one of which, radiating from the digestive cavity ($b \ c$), recedes from the actinal toward the opposite pole, and the other, radiating from the axial funnel (f), is inflected toward the digestive cavity as it passes on to the periphery. Besides the general direction of these two courses, there is another peculiarity which is quite remarkable: the axis of each cell, instead of being a straight line, is curved (*Fig.* 24); so that the main trend of these bodies does not recede in a direct course from the two polar ends of the body, but in long arches. The degree of flexure in these two courses varies in different parts of the body, and may be most appropriately described in connection with the details of this system, to which we now proceed. The shortest span which the radial system makes, lies between the corners of the mouth (*Fig.* 21 a^1) and digestive cavity, and those bands of the interambulacral system which are in the plane of the latter organ, and therefore at right angles to the plane which passes through the tentacular sockets (j) and the two chymiferous tubes ($r \ r$) on each side of the digestive cavity. In this region the cells pass to the periphery in a course which recedes but little from the mouth, and which curves very slightly toward the centre of the body. In the same plane, at the opposite pole, the span is longer, on account of the smaller dimensions of the axial funnel (*Fig.* 23 f), but the trend of the cells is about the same: in fact, they have the same trend and curve as at right angles to this plane (*Fig.* 23 $t \ t^1$) and at all intermediate angles.

But, to return to the actinal pole, we would remark that we find the trend of the radial system (*Fig.* 21 $m \ m^2$) very much modified as we trace it through ninety degrees from the plane of the digestive cavity; for the recession becomes gradually more noticeable, until it reaches its maximum in the region where (*Fig.* 23 m^2) the cells pass to the tentacular sockets (j) with a trend of forty-five degrees to the axis of the body. The span, which is so short opposite the corners of the mouth and digestive cavity, gradually increases in length, until it attains to the longest reach in passing to the chymiferous tubes ($l^1 \ l^8$ and $l^4 \ l^5$) which embrace the tentacular sockets (j); and then the latter, by obstructing the way, suddenly shorten it by more than one half.

This will be more fully comprehended as we now proceed to describe the several points of attachment throughout the system. The cells which radiate from the corners (*Fig.* 21 a^1) of the digestive cavity and thereabouts occupy at their outer ends the whole breadth of the nearest interambulacral band (A, E) of the peripheric system; while those which arise from the sides of the digestive cavity, midway between its corners (a^1) and the vertical tubes (r r) which embrace it, terminate against the four chymiferous tubes (l^2 l^3 and l^6 l^7) which lie nearest to the oral plane. In this as well as in the instance of the other four chymiferous tubes, nothing but their thin wall separates the motory cells from the circulating fluid, and therefore this system must have an immediate and direct influence upon the diameter of these channels. The four peripheric bands (B, D, F, H) which lie intermediate to those in the oral and tentacular planes receive the outward prolongation of all those cells which arise at the median third of the digestive cavity and close upon the vertical chymiferous tubes (r r). The four peripheric chymiferous tubes (l^1 l^8 and l^4 l^5) which trend nearest to the tentacular plane receive the ends of those cells which arise from the vertical tubes (r r) on the sides which face toward the corners of the digestive cavity. The two peripheric bands (C, G) which lie in the tentacular plane have no connection whatever with the radial system, excepting a very small part of their terminations, which extend beyond the opening (j^1) of the tentacular sockets and toward the abactinal area; but all those cells (*Fig.* 21, and 23 m^2) which radiate from the vertical tubes (r r) in proximity to the tentacular plane terminate against the proximal side of the tentacular apparatus (k^1 k^2), and occupy the whole breadth of the same. The length of the span of this part of the radial system varies very much, according to the degree of expansion or contraction of the body; but it usually decreases in the direction of the main chymiferous tubes (c c). In the oral region this system merges into the lateral system along the tentacular plane, the cells of the former (*Fig.* 23 m^2) having the same general trend as the latter (m^3), which radiate from the base (j^2) of the tentacular sockets to the oral area.

It is a difficult matter to distinguish the two systems from one another, when they are seen in profile. But, by a study of the boundaries of the lateral system from another point of view (*Fig.* 21), we find that all those cells which radiate from the tentacular sockets to the oral area, even close up to the terminations of the vertical tubes (r r), belong to this system; whereas only those cells which radiate from the aforesaid vertical tubes belong to the radial system in this plane. In regard to that portion of this system which radiates from the axial funnel (f), we have only to add a word or two, to point out, partly in reiteration of what has already been stated, the fact that the cells (l l^1) trend altogether from one axial line toward the periphery, and are only interrupted at two opposite points by the tentacular sockets (j).

Next to the radial system, the *lateral system* (*Fig.* 21 $p\ p^1$, and *Fig.* 23 p^1) is the largest, and, of the two, the most curiously arranged. The tentacular apparatus ($h^1\ h^2$) may be said to be the basis of this system; at least, from these two points all its cells radiate to the periphery. In a view from the oral end of the body (*Fig.* 21), each half ($p\ p^1$) of the system presents an outline which reminds one of the wings of a butterfly, the tentacular apparatus simulating the body of the insect: nowhere do we find the cells trending in straight lines, but always in gentle curves, whether it be toward the oral plane or in the tentacular plane, or to all intermediate points of the periphery; or whether, as a profile view shows (*Fig.* 23), toward the oral area, or in the opposite direction toward the orifice of the tentacular sockets, or to all intermediate points. In order to simplify the description as much as possible, we will speak of the curved rows of cells as of the cells themselves, which is the more appropriate since the long curves are made by adding one curved cell to the end of another. In the first place we would mention the important fact, that the tentacular sockets (j) alone form the basis of this system, and that the tentacular apparatus proper ($h^1\ h^2$) has no connection whatever with it. As we see it from the oral end (*Fig.* 21), the inner and proximal face (p^2) of each of the four wings of this system forms the hypothenuse of a right-angled triangle, of which the oral and tentacular planes constitute the other two sides. Properly speaking, this face is the hypothenuse of a spherical triangle, since it makes one continuous curve from the edge of the tentacular socket (j) to the median line of that peripheric band (A, E) which is bisected by the oral plane, and meets its corresponding hypothenuse from the opposite side, at a very acute angle, all along this line, to the end (n^6) of the band, and then the edge of this face diverges from the oral plane and follows the outlines of the oral system (m^1) to the tentacular plane. It will be readily inferred, that the greatest span of this face is on a level with the equatorial plane of the body, and that it gradually shortens toward the oral region, and also in the opposite direction. If we follow it along its attachment to the tentacular socket toward the oral area, we find that it meets the face of the wing on the other side at a short distance from the bottom of the socket; so that the two faces form one continuous surface, which arches, as it were, over that portion (*Fig.* 23 m^2) of the radial system that lies in the tentacular plane. The bottom (j^2) of the tentacular socket projects considerably beyond the base of the tentacular apparatus ($h^1\ h^2$), and is free from it; and it is where the wall of this part of the socket joins the terminal edge of the tentacular base that the margins of the above-mentioned faces come together. If, now, in looking at this face in profile (*Fig.* 21 p^2), — as we may do by viewing it from the oral end of the body, — we follow it with the eye from the equatorial region toward the oral area, its component cells gradually change their trend, in order to point in a general way perpendicularly to the curvature of the periphery of the body, and become by degrees foreshortened, until they point directly at the eye from the bottom of the socket. In a profile view of the sockets (*Fig.* 23), the cells at the last-mentioned place (m^3) trend in lines at right angles to the line of vision, and therefore directly toward the oral area; whilst, now, the cells in the equatorial plane point directly at the eye.

The merging of this into the radial system at this point, we have already indicated; but the precise line of juncture of the two may be better and more clearly described now that the boundaries of the former have been distinctly traced. Where the oral plane strikes the inner face (*Fig.* 21 A, n^1) of the opposite peripheric band, the cells of the two systems in question trend so nearly in the same direction as to make it very difficult to distinguish them apart; and, in truth, it is only when seen from the horizontal end that the oral curve (p^2) of the cells of the lateral system furnishes the means of eliminating them from those of the radial system. This apparent confusion of the peripheric borders of the two systems obtains all along the median line of the peripheric band just mentioned to its termination, and then along the borders of the oral system (m^1). The cells (p^3) cross each other at wider and wider angles, until, half-way between the oral and tentacular planes, they mutually traverse one another at right angles, and then again their trend grows more and more nearly parallel, till they run in the same direction side by side at the tentacular plane. At the latter point the parallelism is more perfect, and extends deeper into the body than along the median line of the peripheric band; and, in a profile view of the sockets (j), that part of the radial system (m^2) which passes from the tentacular apparatus to the vertical chymiferous tubes (r r), seems to be one and the same with the lateral system (m^3), which radiates from the base of these sockets. In passing to the several bands (A, B, C, D, E, F, G, H,) of the peripheric system, and to the chymiferous tubes (l^1 to l^8), the cells of the lateral system preserve the same curve, both horizontally and vertically, as along the hypothenusal face. As we have already remarked, these cells trend very nearly parallel with those of the radial system, where they meet along the median line of the peripheric bands which are in the oral plane, and, as we pass around the periphery toward the tentacular plane, we here also find the two, abutting against the several bands (A to H) with a like trend; but it is only at the periphery that this parallelism obtains, whilst towards the axis of the body the cells cross at all angles between the most acute and a right angle, according to their position: thus those cells which radiate to the peripheric inter-ambulacral band (A and E) in the oral plane, cross the radial cells which proceed from about the corners (*Fig.* 21 a^1), from the outer third, and from the median third of the digestive cavity, severally at a very acute angle, at an angle of about forty-five degrees, and at a right angle; and after the same manner all the cells of the lateral system, receding from their peripheric terminations toward their bases, cross those of the radial system. It must be borne in mind, however, that these various angles of traverse are not as if formed by lines coursing on a plane, but as if on the surface of a sphere; that is, they are spherical angles.

This, in general terms, may be said to be the relation of those cells of the radial and lateral systems which lie between the equatorial plane and such a plane as would divide the body by traversing it on a level with the basal ends (*Fig.* 23 j^2) of the tentacular apparatus; but beyond this zone and towards the mouth, the relations of these cells change very rapidly: within the zone the cells of the lateral system diverge from the tentacular socket about at right angles to its axis, but beyond this they diverge at a gradually lessening angle, till at the tip of the socket (j^2) they trend, as it were in direct continuation of its axis, to the nearest point in the periphery, somewhat in the same manner as the hairs project from the tail of a squirrel along the sides and at the end. As the cells of the radial system do not penetrate the spaces which intervene between the tentacular sockets and the interambulacral bands, which the plane of the former bisects, the cells of the lateral system are here left free to act by themselves.

The motory system of the tentacles is so intimately interwoven with their whole structure, that it is most convenient to describe it when presenting the anatomy of these organs in detail; but we will make one or two remarks in this connection in regard to the relations which their different walls bear to those of the body. Although the outer wall (*Fig.* 15 β β' β'', and p. 235 *Fig.* 87 β'' β''') of the tentacular base is composed of much smaller and differently shaped cells from those of the sockets (j j^1 j^2), yet we must believe that the walls of the two are essentially one continuous layer; and, referring to what we have previously ventured to suggest, that these sockets are depressions in the interambulacral layer, and also that the whole tentacular apparatus is a prolongation of two opposite points of the peripheric system, endowed with the faculty of more extensive motion than the basis from which it arises. Any one familiar with the very simple tentacular apparatus of Bolina, Chiaja, LeSueuria, and Euramphæa, will readily comprehend that whilst in them the tentacular sockets are shallow depressions from which the peripheric prolongations arise, in Pleurobrachia these sockets differ only in degree by being more deeply plunged into the mass of the body. The inner wall (*Fig.* 15 g^2 and *Fig.* 87 γ γ') of the tentacle (k) and its base (g γ), although very thick at the latter point, is, to all appearance, identical in cellular structure and continuous with the thin wall (*Fig.* 87 γ'' γ''' e) of the chymiferous tubes, which we have next to describe. Throughout the whole extent of the digestive cavity and chymiferous system, the wall is composed of extremely elongated cells, which, trending lengthwise with the tubes, give them a finely striated appearance, as if they were composed of filaments laid parallel to each other. In the wall of the bulbous forks (*Fig.* 14 f^1 f^2) of the axial funnel, these cells trend lengthwise, like meridians of longitude, converging at the two obliquely opposite apertures, the anterior and the posterior cœliac openings (ζ ζ). The only place where this wall varies from one uniform very thin layer is where it constitutes at the same time the inner wall (*Fig.* 87 γ γ^1) of the tentacular base; and there it is of variable thickness, as has already been described.

The vertical rows of locomotive flappers are entirely superficial. Each row consists of a great number of isolated, transverse, comb-like bodies, placed one above the other, and movable, either isolatedly or in regular succession or simultaneously. Each comb consists of a large number of ribband-like bristles, slightly arched upward and downward, of which the middle ones are the longest, tapering gradually sideways; so that the combs are, properly speaking, crescent-shaped, with a straight base, the teeth or fringes of which are movable in quick vibrations up and down, independently in each comb, and even independently to some degree in each portion of the same comb, as the middle fringes may be seen to move when the lateral are motionless, and the reverse. But, generally, all the fringes of one comb act simultaneously; but the motion in all the many combs of one row is successive, so that, when the combs are very active, they seem like waves moving up and down in rapid succession along each vertical row, or like the waving spikes in a corn-field agitated by the wind. Again, the undulations of the different rows are independent,—sometimes all the rows playing at the same time, at other times parts of the rows, or parts of each row, or parts of some rows, playing independently. Pleurobrachia moving with the mouth forward, the prevailing direction of the locomotive flappers is toward the abactinal pole, while in Bolina and Idyia it is toward the actinal pole.

The number of teeth or fringes in one of the larger combs may be about fifty; but they are not equally numerous through all the combs in one vertical row. The combs in the upper parts and in the lower parts of each row nearer the mouth and the area opposite are gradually shorter and shorter, and contain fewer and shorter fringes, the largest being about the middle of the vertical height. They terminate more abruptly and at a greater distance from the centre on the actinal than on the abactinal side, where they are naturally prolonged toward the central eye-speck.

The movements of these flappers seem at first to be identical with those of vibratile cilia; and one might be tempted to suppose that they are formed by a row of compressed vibratile cells, arranged in such a manner as to bring their cilia in one row, and the cells themselves in such superposition above each other as to form vertical series. But the cilia or fringes are far larger than any vibratile cilia ever described, and their motion shows distinctly that they are under the voluntary control of the animal; for their movements are neither incessant nor constantly equal. They are at times accelerated or retarded, or entirely stopped, and resumed at shorter or longer intervals; so that the evidence of their voluntary movement is as full as can be, and, indeed, the structure which determines the movements is the same as in all cases of voluntary motion.

Fully to understand the character of the vertical rows of locomotive flappers, it should be borne in mind that they are connected for their whole length with vascular tubes following the same course, and which arise from the central chymiferous cavity. This intimate connection leads naturally to the supposition, that, besides their functions as locomotive organs, the vertical rows of flappers are in some way connected with respiratory functions, and that there is between these two systems the same natural physiological connection which exists in Echinoderms between the inner branchiæ and the ambulacral tubes, or in Worms between the respiratory vesicles and the locomotive bristles.

The circulation of fluids, and the respiratory movements connected with this circulation, are, almost throughout the animal kingdom, in direct relation to locomotion, even in the higher animals. Among Polypi, the dilatations and contractions of the body renew constantly the water which fills their cavity, and provide them with a fresh supply of aerated water. The same is the case among Medusæ. For, even where there is no distinct, individualized system of respiratory organs, it is obvious that a constant renewal of the surrounding medium, by means of which oxygenation takes place, is an essential condition for the maintenance of life; and where there are no special organs adapted to this purpose, the main movements of the body supply the deficiency. The water-pores in Echinoderms, through which their main cavity is constantly filled with fresh sea-water, undoubtedly perform a similar office. Again, among Mollusca, respiration and locomotion are still more intimately connected; but in a manner which differs decidedly from what we observe in higher animals. For here, by the dilatation and contraction of the respiratory cavities, and the circulation of the blood through the respiratory organs, the body is amply supplied. But, unless Acephala open their valves, unless they expand and contract alternately the whole body, the supply of fresh aerated water must be much less; and I doubt whether oysters and clams could be kept alive if their valves were shut constantly by pressure, and muscular motion, the contraction and expansion of the large bundles which preside chiefly over locomotion, were prevented from coming into play in aid of the vibratory cilia of the mantle and gills. The manner in which the respiratory cavity is shut in so many Gasteropods, unless the fleshy parts are fully expanded, shows plainly that here again there is an intimate connection between respiratory movements and locomotion. In Cephalopoda this is still plainer; for, from the form of the respiratory cavities, and from the disposition of the sacs in which the gills are placed, we can easily infer that the contractions and dilatations of these sacs, by which the water is renewed, must afford a material mechanical assistance in the progress of locomotion. Again, throughout the type of Articulata this connection is most intimate, the respiratory organs being directly connected with the locomotive appendages, and forming, indeed, part of the various kinds of oars, fins, legs, and chewing appendages, by which the principal motions of the body are sustained. Not a joint can be moved here, without influencing respiration; and, again, the expansion and contraction of the respiratory cavities, the filling of the respiratory vesicles or the large circulatory sacs connected with the gills or fins, and the introduction of air into the tracheal tubes, must, in their turn, influence locomotion. It is a subject worthy of the attention of physiologists, to trace more minutely this double connection throughout the animal kingdom. Perhaps the type of Articulata is best adapted to make a beginning in these investigations. For among them, in the Crustacea for instance, the chewing of the food itself is directly connected with the process of respiration. The motion of the jaws aids in forming and maintaining a regular current of water along the gills through the respiratory cavities; and, even when not otherwise employed, the jaws are kept in motion in some degree to assist respiration. And it can hardly be doubted, that the process of respiration also materially aids the Insects in their flight, and that the degree of expansion or contraction of the respiratory cavities is very different in the state of repose or during flight. While watching grasshoppers I have often been struck with the wide expansion of their abdomen at the moment of starting, and with the collapsed condition of the whole body soon after they have alighted, which is even so great as to prevent their rising again immediately when chased.

Again, among Vertebrata we find in Fishes that the respiratory movements — the lifting and shutting of the operculum, the filling and emptying of the branchial cavity — aid the fish in slowly progressing; so much so, that, when resting upon the bottom of a glass jar, apparently immovable, these animals are at times suddenly propelled forward under the action of a powerful occasional contraction of the branchial cavity, even though the ordinary locomotive organs — the tail and fins — remain absolutely quiet. How close a connection exists between locomotion and respiration in the Ichthyoid Batrachians, I have often had occasion to witness in a Proteus kept in confinement, in which the gills grew gradually paler and paler when the animal was absolutely motionless, but would instantly be filled with a large quantity of blood and appear intensely red after some violent motion. It might be objected, that this is a mere influence of locomotion upon circulation; but if there were not this natural disposition in all locomotion to influence the process of respiration more than any other system, why should not the blood, when such powerful motions take place, be accumulated in any other part of the body,— for instance, in the tail, which is the very cause of the motion,—rather than in the gills? In Birds, the extensive development of the lungs, and the prolongation of air sacs into the abdominal cavity, the wings, and the sternum, in those most remarkable for their power of flight, plainly indicate again the most strict connection between locomotion and respiration, though the nature of this connection is perhaps different from that observed in the lower classes. Nevertheless, it exists even in these, and can be traced to a very remarkable extent. We cannot fail to trace similar relations among Mammalia also, though here the influence between the two functions is not so direct. However, it must be acknowledged that it is important enough, when we consider how the aquatic types have to accommodate all their movements to the wants of the system for atmospheric air, and remain constantly within reach of the surface, in order to be able to return to it in a short time. How much the breathing is affected by violent movements is so well known to every one, that the existence of accessory muscles of respiration in Mammalia, the antagonism between the pectoral and abdominal muscles and the diaphragm, and the use of belts by athletes in running, leaping, or wrestling, need only to be mentioned as evidence of this mutual relation. Of course, in animals in which all the functions have reached a great degree of independence, they are no longer subservient to each other to such a degree as they are in the lower types; but even the unpleasant influence which excessive exercise of the locomotive powers has upon respiration in the higher animals, shows the intimate relation which prevails in the plan of organization.

It has already been mentioned, that there is a wide chymiferous cavity in the centre of the body of this animal, trending in the vertical direction of the digestive cavity; but the natural relations of these parts are so difficult to appreciate, the ramifications of the chymiferous tubes so complicated and nevertheless so regular, and again so movable in their constant contractions and dilatations, that, with all the assistance of numerous drawings as given in my paper in the Memoirs of the American Academy, I hardly expect to be able to give a correct idea of this apparatus, unless the reader is willing to consider attentively every point of the following description by itself, and to keep at the same time constantly in mind the relative connection of all parts, and their bearing upon the general appearance of the body.

In the first place, let it be remembered that the central chymiferous cavity and its main trunks undergo constant changes as to their size and outlines, according to their temporary state of contraction and dilatation, and that both halves of the system of tubes which arise from the main cavity and branch into the right and left halves of the body alternate constantly in their contractions, — so much so that the one may be in the state of fullest expansion when the other is in the most complete state of contraction; and after a while the reverse will take place, when the last will be fully expanded and the first fully contracted. But in these alternate movements there is a moment when both halves are in a state of apparent equilibrium, though one be in the process of emptying and the other in the process of filling; while at the moment an equal amount of liquid has been pressed from that half which is contracting into that half which is filling, the symmetry is most complete. These alternate contractions are nearly as regular as the movements of diastole and systole of the heart, and take place by a constant balancing of the fluid one way and the other. The difficulty of watching this singular circulation arises chiefly from the necessity of keeping the living animal in one and the same position, as the slightest obliquity will interfere with the perspective, so as to make it altogether impossible to follow the natural movements; and unless the parts are placed in a strictly identical position, those which are in pairs will create confusion, as they may come into various positions, presenting apparently a close connection with parts to which they are not at all related. Again, the peripheric tubes extending in vertical arches over the surface, cover so easily the origin of the different trunks arising from the main cavity, that it is indeed very perplexing to trace them all in their true connection. Add to these difficulties the circumstance, that the arrangement of parts, owing to the bilateral symmetry of the body, appears entirely different when viewed in profile, from the side, or in front, and it will be plain, that, unless the observer keep in mind several distinct images of the various connections of all these stems and their ramifications, in a front view and in a lateral view, combining them in thought with the rapidity with which such an animal may revolve upon itself, it will be impossible for him to trace for a moment its structure while alive; and he will only have constantly before his eyes the tantalizing image of a piece of machinery, apparently very complicated, the structure of which he has to decipher while it is moving, but moving almost too fast to allow him to seize the connection of the different parts as they pass along, and which is not only deranged, but destroyed, the moment it is stopped. It was under such circumstances that I undertook to study the circulation of these animals; and though I succeeded in injecting indigo into their main cavity, and in having it circulate for hours at a time within the body of the same animal before it died, and though I was satisfied that not a particle of the colored liquid had passed into any part of the body into which the liquid before it was colored had not naturally free access, and though it was thus plain to me, that, even after being colored, the circulating fluid continued its normal course, I must say that

I never investigated a more difficult subject, never had to devote so much time to the same point, and never taxed my patience to such an extent as during these investigations. I insist upon these details, and state them at full length, because I know that I have now cleared up this subject, and may perhaps induce some other student to go through the long description I am about to give of it, since he may expect to have the matter settled for him. Let us proceed in this description as we should with a minute description of the ramifications of the bloodvessels of some highly organized animal. The difference which exists between the digestive cavity and the main cavity of the chymiferous system will first engage our attention.

In a front view (Pl. II^a. *Fig.* 23), when the two tentacles appear right and left, and the plane which passes through the longitudinal fissure of the mouth divides the body into halves, we have before us, on our right, one of those halves of the body, which alternates in its contractions with the other half on the left. It is according to this diameter that the antagonism between the two sides is introduced. Seen in this view, the digestive cavity appears throughout like a narrow fissure (*b c*); but as it is much wider in another direction, its outline, as seen in *Fig.* 22, is very broad. The fact is, this cavity is a flattened sac, flat as long as it is not full of food, and the two surfaces of the flattened bag are pressed upon each other: so that when seen in profile, that is to say, facing the diacœliac diameter of the body, as in *Fig.* 23, it appears like a mere double skin, or a slit lined with a membrane; but when seen from its broadside, that is to say, facing the right or left side of the body, as in *Fig.* 22, it appears like a wide sac. During the process of digestion, when filled with food, it is swollen into a more rounded sac or cylinder. The abactinal extremity of this sac opens into the main cavity of the chymiferous system, terminating there in an oblong fissure, which, at the will of the animal, can be shut or opened; so that, like the stomach of Actinia, the digestive cavity of Pleurobrachia communicates with the chymiferous cavity, or may be shut by itself. The difference between the two types, however, consists in the limitation of the cavity of the body, which is circumscribed within the centre of the animal in Pleurobrachia, and sends off large trunks and tubes, branching diversely into its mass and along its surface; while in Actinia the whole body is hollow, and the stomach empties into that one large cavity.

The central chymiferous cavity has two main stems, one extending into the right, and the other into the left, half of the animal (*Fig.* 23 *c c*). It would seem, from *Fig.* 23, as if the digestive sac (*b c*) were hanging loosely into the chymiferous cavity: this is, however, not the case, for the spaces (*r r*) which communicate with the main chymiferous cavity right and left of the digestive sac do not form a continuous cavity encircling the whole digestive sac, but are only two simple but rather wide tubes arising from the main trunks of the central chymiferous cavity, and following the middle of the lateral surface of the compressed digestive sac in a vertical course up to the margin of the mouth, as *Fig.* 21 *r r* shows. Toward the abactinal pole, however, the main cavity extends in the form of a funnel, and terminates with two holes near the centre of the circumscribed area. This funnel lies vertically in the centre of the animal, and extends therefore in its central axis. It assumes nearly the same appearance in whatever position it is seen, excepting only its abactinal termination, which is furcate when seen from the side, as in *Fig.* 22 f^1 f^2, and simple when seen in front, as in *Fig.* 23 f^1. This part of the cavity with its main lateral trunks being, as it were, the centre of the circulation, we may view it as a hollow axis branching right and left, and extending along the centre in two parallel forks, one on each side of the digestive cavity, as far as the mouth; so that, when examined from the side, only one of the two actinal forks is visible behind the tentacular socket, while the short abactinal forks, which are at right angles with the former, are both distinctly seen, and *vice versâ*. The main lateral stems and their ramifications present their broad side in the last position, and appear foreshortened in the other.

The two main lateral trunks (*Fig.* 23 *c c*) branch off at right angles from the central cavity, and extend sideways and for some distance horizontally, with a slight inclination towards the actinal pole, changing however their position to some extent, according to the state of contraction or distension of the digestive cavity. Six branches, or rather three, if we take their closer connection into account, arise on each side from these main trunks, besides those which are close to the digestive cavity. The fact is, that after giving off the cœliac tubes and before branching again, the two main trunks form, at their extremity, sideways, a sort of dilatation, from which arise two lateral branches extending horizontally backward and forward, and two others close together which extend in a vertical direction. The branches extending horizontally forward and backward give out, not far from their origin, two other branches, which also extend horizontally, but bend sideways, nearly at right angles with the former. All these branches originate so near the point where they communicate with the primitive main trunks, that they might, with almost equal propriety, be considered as arising directly from it. The termination of the main trunk may, indeed, contract or dilate in such a manner as to appear alternately divided into three, four, five, or six branches. In its most contracted state, for instance, when seen from the actinal pole, as in *Fig.* 21, there are distinctly six branches visible, arising from the main horizontal trunk, the two vertical ones appearing like very short tubes, because their whole length is foreshortened upon their origin, though they are actually as long as the others, while the four horizontal branches are seen for their whole extent, — two and two however, united by their base; so that it may with equal propriety be said, that, on the whole, there are only four tubes, the two horizontal ones branching soon again into two. In the dilated state of the main trunk, but when the branches arising from it are in a state of contraction, these all seem to originate from one common cavity, and the four horizontal tubes appear independent of each other, while the two vertical ones are brought so close together as to look like one,—making altogether five branches. In another state of contraction, the two vertical tubes may seem united, and the two pairs of horizontal ones also, when there appear to be only three branches to the main trunk. Unless the dilatations and contractions of these curious ramifications of the stems have been watched for a long time, these differences may remain unnoticed; but when fully understood, there is no contradiction in the apparently conflicting statements, that there seem at times to be three, at times four, at times five, and at times six branches, to the main trunk. I should add, that when seen from the actinal or from the abactinal pole, unless the body is somewhat inclined, the vertical tubes altogether escape attention, and that the best position to ascertain their relative connection is an external side view, as in *Fig.* 15. In *Fig.* 22, which represents the whole system in the same position as *Fig.* 15, the view of the horizontal main trunk and its branches is somewhat confused, from the circumstance that it is projected upon the vertical central cavity and the actinal prolongation of that cavity upward and downward; but in *Fig.* 15 we have only the peripheric branches arising from the main trunk, that is to say, the portion seen to the left in *Fig.* 23, while in *Fig.* 22 we have, besides that half, the central axis also, as likewise in *Fig.* 23.

I have described these peripheric branches as horizontal,—and so they appear when seen from above or from below; but in a vertical position they are seen to be somewhat deviating from a horizontal plane, the anterior and posterior branches reaching the periphery at a greater distance from the abactinal pole than the lateral branches, and the vertical branches inclining slightly outward. These different branches have by no means the same functions, and are not connected with the same apparatus; the vertical branches, which I have called interambulacral or tentacular tubes, extending to the disk from which the tentacles are protruded, while the horizontal branches communicate with vertical tubes,—the ambulacral tubes,—which follow the inner surface of the vertical rows of locomotive flappers for their whole extent.

As there are on each side four such horizontal branches and four vertical rows of locomotive flappers, there are also, in the whole, eight vertical superficial chymiferous tubes, widest in the middle, and tapering upward and downward, which are in direct communication with the central chymiferous cavity through the four horizontal tubes and the two main trunks, from which they themselves arise. The actinal ends of the superficial vertical tubes, which I may call the ambulacral tubes, terminate as blind canals; at least, I have been unable to trace a direct communication between any of them and the vertical tubes which follow the sides of the digestive cavity, though such a communication is seen in the genus Bolina, as I shall mention hereafter. The fluid circulated upward through these tubes can be distinctly seen to retrace its way downward; so that, in the ascending branch of the ambulacral tubes, the fluid injected through its horizontal branch is moved up and down alternately. This is also the case with the lower branch of the same vertical tubes, and, though the abactinal end tapers more gradually, it terminates also in blind canals; and I was mistaken in formerly supposing them to open again into the main cavity. The movement in reality takes place in the following manner. Each of the eight horizontal tubes fills its vertical ambulacral branches, the fluid flowing, at the junction of the vertical tube with the horizontal stem, in opposite directions, upward and downward; then, flowing back through the same channels during the contraction of the mass of one side of the body, it is pressed into the horizontal tube, and returns to the centre of the movement to pass into the opposite side of the body. There can be no doubt, that the liquid moves decidedly to and fro in the ambulacral tubes and returns to the central cavity through the horizontal tubes, and that the dilatation of the four tubes of one side alternates with the dilatation of the four tubes of the opposite side; but in each vertical ambulacral tube the motion of the fluid is an undulatory one, owing to the alternate dilatation and contraction of the tube itself.

The movement of the fluid in these tubes can be traced very satisfactorily when following the course of the minute granules of colored matter suspended in the water after injection; but even in fresh uninjected specimens, the circulation can be tolerably well traced by watching the small particles of undigested food suspended in the mixture of water and chyme which is circulated throughout this system. As in Polypi, the whole mass of digested food, comminuted and reduced to a very uniform state, but in which the parts capable of being assimilated are still mixed with parts of the refuse matter, is emptied bodily into the chymiferous cavity, and, with a certain quantity of water introduced in the same way into this cavity through the mouth, kept in a constant, regular, undulatory circulation throughout life. But as there is a double outlet through which this system can discharge its contents on the side of the circumscribed area, the circulation is more or less active, all the tubes more or less turgescent, and the whole cavity more or less dilated, as the quantity of fluid in circulation is greater or less; which, to some degree, changes the relative position of the tubes and of the central cavity. When very full, the wider central space is considerably raised; while in a state of relaxation it sinks lower down, nearer the abactinal extremity of the body. As long as the circulatory system is relaxed, the ambulacral tubes are very much contracted, and their diameter is much less than under other circumstances, and by no means equals the width of the vertical rows of locomotive flappers; but when turgescent and full, they swell beyond their width. The force which acts in propelling the liquid through the system is not the same throughout. The alternate contractions of the two sides result from the regularly alternating muscular contractions of the two sides of the body; but the main cavity in its central part is entirely lined with vibratory cilia, so that even when the body is perfectly at rest, the fluid is maintained in a constant rotatory motion through their agency. I have repeatedly and distinctly seen these cilia playing round the abactinal opening of the digestive cavity, and upon the walls of the central chymiferous cavity, as well as upon the walls of its main horizontal stems, upon the walls of the cœliac tubes, and upon the walls of the two forks of the funnel. I have been unable, however, to discover similar cilia within the secondary horizontal tubes and the vertical ambulacral tubes; though recently I have noticed them in the vertical tubes of the tentacular apparatus, where I had failed to discover them before. However, the contractions of the spherosome are so powerful that the vibratory cilia can do but little, of themselves, to keep the fluid in motion in some of these tubes. I should also add, that even the walls of the central chymiferous cavity, where they are most distinctly lined with vibratory cilia, are nevertheless distinctly contractile; and that the capacity of the cavity is not only increased and reduced in a passive manner by the accumulation of fluid or its expulsion, but also actively by the contraction and dilatation of the walls themselves. How the contents of this circular system are diffused into the substance of the body for nourishment is not very plain, as there are no capillaries, but everywhere broad tubes. From the cellular structure of the whole mass, however, we may infer that assimilation takes place by a process of endosmosis and exosmosis. If this view is correct, we should consider the two cœliac tubes upon the middle of the main walls of the digestive cavity as the nourishing vessels of the stomach; the two horizontal trunks as two respiratory vessels, branching into eight branchial vessels, which are the main trunks of the eight ambulacral vessels; and the vertical funnel as a vascular cloaca, discharging its contents through two distinct apertures, the cœliac apertures, on the sides of the circumscribed area near the abactinal centre.

The vertical tubes of the tentacular apparatus seem to have a peculiar function, and to be directly connected with the movements of the tentacles, and these movements again to be connected with the alternate contraction of the two halves of the body, as there are no parts which undergo so extensive changes in their size, and in their state of contraction and dilatation, as these sacs. But their structure is so complicated as to require a minute description. The two tentacles with their elongated cavity, and the vertical tubes extending along the base of the tentacular apparatus, constitute, indeed, most complicated pieces of machinery, in which hydrostatic power, elastic levers, and the contractions of the motory cells, give rise to highly complicated combinations and most diversified phenomena.

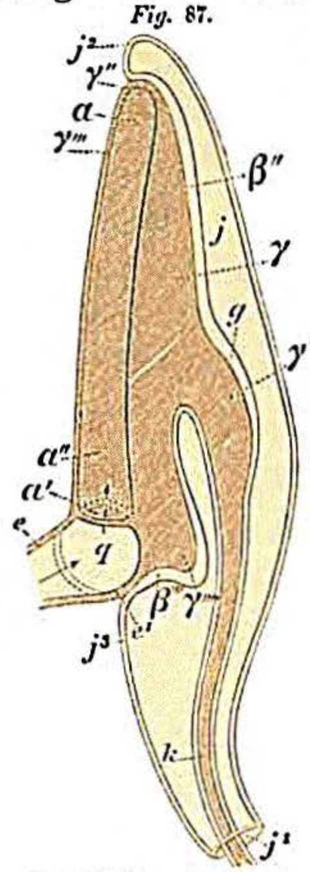
In the first place, the cavity itself from which each of the two tentacles issues (Pl. II^a. *Fig.* 15 $j\ j^1$, *Figs.* 22 and 23 j) is a wide, elongated, fusiform sac, the rounded extremity of which is turned towards the actinal pole and bent obliquely sideways, so that its flat base is turned towards the vertical axis, and its open extremity towards the abactinal pole and sideways. In this cavity, to which the surrounding water has free access through the opening j^1, the tentacle with its complicated base is attached by a broad surface to the inner side of the sac. And though the central chymiferous cavity communicates freely, through the interambulacral tubes, with the base of the tentacular apparatus, there is no free passage from one of the cavities into the other. The fluid which is injected into the tentacular tubes runs back through the same channels into the main trunk, and the water which fills the cavity of the tentacular apparatus empties through the same opening by which it is introduced. In a state of dilatation, water penetrates from without into the tentacular sac, and diluted chyme is injected from within into the tentacular tubes; and in a state of contraction, the chymiferous tubes are emptied at the same time that the water is pressed out. During these alternate contractions and dilatations, the tentacle itself may be coiled up in the cavity or drawn out at full length, though in the most dilated state the threads generally hang out. There seems to be also an antagonism, in a middle state of dilatation, between the filling of the tentacular chymiferous tubes and the protrusion of the tentacles themselves. But I was mistaken formerly, when supposing that the chymiferous tubes penetrate into the basal dilatation of the tentacles:[1] they only extend along their basal disk. The filling of these tubes may, however, cause the whole tentacular apparatus to protrude into the sac to which it is attached.

Nearly two thirds of the length and breadth of the proximate side of the actinal or closed end (*Fig.* 87 j^2 to j^3) of the tentacular socket is occupied by an oblong disk (Pl. II^a *Fig.* 15 and *Fig.* 87 $\beta\ \beta'\ \beta''\ \beta'''$, $\gamma\ \gamma'\ \gamma''\ \gamma'''$), from the mid-length of which the tentacle ($g\ \gamma'\ k$) arises. The distal side (*Fig.* 15 β) of the disk, or that which faces toward the periphery of the body, is convex, with a shallow furrow (*Fig.* 15 γ), extending from the base (g) of the tentacle to the actinal end (γ'') of the disk; and the proximate side (*Fig.* 87 γ'''), or that which faces toward the axis of the body, is a plane, immediately beneath whose surface and next to the edge

[1] When comparing the plates of my paper in the Memoirs of the American Academy, allowance should be made for this mistake, which is especially noticeable in *Figs.* 1 and 2 of Pl. IV.

(*Fig.* 15 β'), two chymiferous tubes ($\alpha\ \alpha'\ \alpha''\ \alpha'''$) run parallel; leaving between them, along the median line, a thick ridge (*Fig.* 15 γ), which is nearly as broad as the diameter of the tubes. The relations of these parts, as seen in profile, may be better understood by referring to the annexed wood-cut (*Fig.* 87) and the accompanying explanation, at the same time comparing it with Pl. IIa. *Fig.* 15, which is lettered correspondingly. The thickness of the disk as a whole is equal to about two thirds of the breadth, but it thins out at the actinal end (γ'') in just about the same proportion that it narrows; whereas at the other extremity (β'''), where it is slightly narrowed, it is thickest, and also terminates abruptly directly opposite the junction of the main chymiferous trunk (q) with the two parallel tubes ($\alpha\ \alpha'\ \alpha''$) just mentioned. It seems appropriate to compare the shape and proportions of this disk to a flat-soled, broad shoe-last. The structural details of this organ appear very simple, when once fully understood; but, owing to the fact that it is situated at the bottom of a deep socket ($j\ j^1\ j^2$) and as if plunged into the midst of other organs, it seems to be quite complicated. Only imagine the socket to be removed or reverted, as oftentimes does happen in a great measure, and the whole apparatus will appear like a peripheric ridge, which, at one point, is drawn out into a slender thread, the tentacle. The base (*Fig.* 15 $g\ g^1\ g^2$) of the tentacle has the form of a high, narrow ridge or keel (*Fig.* 15 $g^1\ g^2$ and *Fig.* 87 γ'), more or less plicated or distorted, according to whether the apparatus is extended or retracted; but we have never seen it projecting beyond the aperture (j^1) of the socket. At the basal end (g) of the keel it is as broad as the disk from which it arises, but it suddenly narrows to a uniform thickness, which it retains to the other

Fig. 87.



Longitudinal section of the tentacular apparatus of PLEUROBRACHIA RHODODACTYLA, *Ag.*[1]

[1] *Fig.* 87 represents a longitudinal section of *Fig.* 15, Pl. IIa, one of the chymiferous tubes ($\alpha\ \alpha''$) being in the distance; e wall of the main horizontal chymiferous trunk; e^1 opposite side to e where it passes into the inner wall (γ''') of the disc; g the base of the tentacle; j tentacular socket; j^1 aperture of j; j^2 apex of j near to where it passes into the outer wall (β'') of the disc; j^3 the inner or proximal side of j where its wall passes into the outer layer (β''') of the disc; k the tentacle; q point of junction of e and $\alpha\ \alpha'$; the dotted lines represent the outlines of the channel which diverges, at right angles, from e (see q^1 *Fig.* 15, Pl. IIa); α the apex of the chymiferous tube; α' entrance to α; α'' base of α; β'' outer wall of the disk; β''' same as β'' at the thickest part of the disk; γ the inner layer of the disk; γ' inner layer of g; γ'' the thin proximal wall of α where it passes into γ; γ''' same as γ'' further along; γ'''' the thickest part of the inner layer of the disk. Designed from nature by H. J. Clark, to correct the mistake alluded to p. 234, note. Magnified.

end, where it merges into the cylindrical part of the tentacle. As the tentacular fringes (*Fig.* 15 k^1) are not to be found upon this ridge, but just at its distal termination, and onward, — and, if we mistake not, the lasso-cells are absent, — it may be proper to consider it as essentially a part of the disk, simply subservient to the movements of the prehensile organ, which is prolonged from it.

There are two distinct walls or layers, which constitute the body of the disk, and which are continued, in the same relation, into the tentacle; but the greater proportion of this apparatus is composed of the inner layer (*Fig.* 87 γ γ' γ'' γ'''), the outer one (*Fig.* 15 and *Fig.* 87 β' β'' β''') being comparatively a very thin stratum. The thinnest part of the inner layer may be found about the proximate side (γ''') of the two parallel chymiferous tubes (α to α'''), which penetrate to the apex (γ'') of the disk, where it occupies one half of their circumference, as a mere film (γ''') of long, slender cells, identical with those which we have already pointed out (pp. 223, 224) as forming the walls of the whole chymiferous system. On the solid side (*Fig.* 87 γ) of these tubes and between them (*Fig.* 15 γ), this layer more or less suddenly becomes very thick; at the distal side of the apex (γ'') of the tubes the transition is comparatively gradual, as one might very naturally infer from the form of the disk; but at all other points the passage, from the filmy wall to the highly incrassated core of the disk, is very abrupt, especially at the abactinal end (γ''''), where it projects like a hook or nose. In the tentacles (k) again it loses its bulky proportions, whilst the outer layer gains the ascendency (within the main stem of this organ the decrease is not so great as in the fringes); in the former the inner layer forms a solid axis, occupying about two thirds of the diameter of the tentacle, whereas in the latter (*Fig.* 13 d, *Fig.* 18 d) it forms but one third of the whole thickness. Along the median line of this layer, in the fringes, there is a slender string (*Fig.* 13 c, *Fig.* 18 c) of matter which is much more transparent than the rest, and has the appearance of a canal; but no distinct cavity could be detected. The course of the longer axes of the cells constituting this layer is very simple. Within the disk it is lengthwise (*Fig.* 15 α), and in a general way parallel to the surface of this body; and so, too, in the tentacle and its fringes (*Fig.* 13 d). At the origin of the fringes (*Fig.* 15 k^1) the cells of the main body (k) of the tentacle bend nearly at right angles upon themselves, and enter at once into the former without any break; they are as directly continuous from the one to the other as from the disk into the tentacle. When the tentacle is contracted it is transversely wrinkled, and in this condition the cells which diverge at right angles into the fringes appear to traverse the whole diameter of the main layer as if they were distinct bands, originating independently of the cells of the latter; and this deceptive appearance is all the more heightened if a portion of the tentacle be cut away and laid out on a slip of glass, when the chances are frequent that the fringes will become folded directly across the main stem.

The outer wall (*Fig.* 15 $\beta' \beta'' \beta'''$, p. 218) of the disk and the transversely striate wall of the socket (j j^1 j^2) are directly continuous the one with the other, and together constitute the lining of the cavity which they embrace. The cells (β β') of the disk wall are as broad as they are long, simulating irregularly polygonal prisms, and the inner ends are flattened against the subjacent layer, whilst the outer free ends are rounded. In size they are very large, being on the average from one fifth to one fourth as long as the largest cells (*Fig.* 24) of the cellulo-motor system. At the base (g) of the narrow ridge (g g^1 g^2) they decrease in size very rapidly, and continue to do so until we come to the base of the tentacle proper, at which point we find them diminished in diameter by nearly two thirds; but from this place to the end of the stem and its fringes, the diminution is very gradual, until at the tips (*Fig.* 13 e) of the latter they measure not more than one fourth the diameter of those in the disk. The contents of these cells are perfectly homogeneous, nor have we been able to see any mesoblast. During the contraction of the fringes the surface is ribbed lengthwise, owing to the fact that the outer wall folds upon itself (*Fig.* 18 c c^1), and the inner one (d d^1) projects more or less into the duplicatures. By taking advantage of the doubling of a fringe upon itself, we may get a very satisfactory sectional view (*Fig.* 18) of these walls when in this plicated condition.

The outermost, or epithelial layer (*Fig.* 13 a b and *Fig.* 18 b), of the tentacular apparatus, is described below, and therefore need only be referred to in this connection. Although the wall of the socket (j j^1 j^2) is a very distinct layer, yet it does not hang loosely, apart from the mass of cells which surround it, but it is more like a lining to a cavity which has been excavated in the cellulo-motor system. The transition from the comparatively thick outer wall of the disk (*Fig.* 15 β) to the thin wall which constitutes the cellulo-motor system of the sockets is very abrupt; but yet there is not so sudden a change in the nature of the cellular constituents as would appear at first sight. The only appreciable difference is in the shape of the two kinds of cells, the form of the discal cells being adapted to a different purpose from those of the sockets.

All the extensible parts of the tentacles, as well as their lateral fringes, are covered by a layer of thick epithelial cells, every one of which is a *lasso-cell*.[1] When the tentacle is fully prolonged, these cells scarcely touch each other, and then they display a perfectly rounded contour, excepting a very narrow portion,

[1] The following investigation of the lasso-cells of Pleurobrachia is entirely the work of my friend and colleague, Professor H. J. Clark, who discovered their peculiar structure last year.

which is flattened at the base of attachment.[1] In this condition it is easy to observe that each cell is covered exteriorly by a single layer of exceedingly minute granular bodies (Pl. II^a *Figs.* 7, 9, and 12 *f*). As the tentacle contracts, the lasso-cells become mutually compressed; at first but slightly (*Figs.* 16 and 17), but finally so as to be sharply polygonal (*Fig.* 13 *a*). The granular coating is so dense that the coiled thread within is not so conspicuous as in the lasso-cells of the Discophoræ. Even with a magnifying power of five hundred diameters, it is very difficult to detect the thread whilst the cell remains attached to the tentacle, and then it is seen foreshortened; for a profile view is out of the question, except when the tentacle is stretched to the utmost, and then, owing to its activity, only a mere glimpse can be obtained. The only convenient method of observing them is by cutting off one of the fringes, when with unusual readiness the lasso-cells drop away from their attachment. If now they are placed upon a glass slide they may be rolled about in every direction, and thus exposed in any desired position. No satisfactory elucidation of the nature of these cells can be obtained by using objectives of ordinary definitions, for the granular coating is confounded with every thing else;[2] but, in order to plunge into the midst of the contents

[1] It is not possible to see these cells in this condition unless the objective of the microscope is plunged without ceremony into the water of the deep jar in which these animals must be kept. By gradually cooling the water until it becomes icy cold, a small quantity will serve to keep Medusæ in the full vigor of life, and then they may be observed without mutilation. Unless the brass-work be varnished, the chemical reaction of the sea-water invariably disturbs the animal, and causes it to contract very closely. With a little care, a power of from three hundred and fifty to five hundred diameters may be used.

[2] Gegenbaur, who was the first to publish any thing about these cells (Wiegmann's Archiv, March, 1856, p. 179, Taf. VIII. *Fig.* 12 *ε ε'*), gives a very meagre account of them, and shows that he does not know their typical difference from the lasso-cells of the discoid Medusæ and all Polypi. His brief notice of the lasso-cells of what he considers a new species of Cydippe — but which is probably a new genus — reads thus: "Both the cirrhi and the margin of the appendage are covered by round nettling cells, 0,005‴ in diameter (by mistake for 0,005″, no doubt), which inclose a smooth, spiral thread. If the thread extrudes, it shows the peculiarity of not straightening out at once, as do all other lasso-threads observed by me, but remains for some time in a long drawn out spiral. The end remaining, during protrusion, within the vesicle, stands in connection with a number of round granules, which are grouped in a blackberry-like form." Later in the same year, Dr. T. Strethell Wright (Edinburgh New Phil. Mag. October. 1856) also published a brief notice of these cells, which repeats the errors of Gegenbaur, and adds nothing new whatever. The animal which he examined was a genuine Pleurobrachia, if it was the same as the one he refers to in the July number of the Journal of the same year. He says: "These cells were spherical, and opaque from the presence of molecular matter in their interior. When ruptured by pressure, they were found to contain a simple short thread, more or less closely coiled in a spiral form. The application of distilled water burst the cell walls and uncoiled the threads." From the above it is evident, that neither Gegenbaur nor Dr. Wright had studied the lasso-thread whilst coiled

and see them by themselves, a very flat field is required. With such an objective the field acts like a section upon the walls and contents of the vesicle, and the granular coating can be brought into strict profile (*Figs.* 2 and 7 *f*) and displayed as a single layer upon the outside of the wall of the cell, whilst the interior surface of the same wall is proved to be lined by the spirally coiled lasso-thread (*Fig.* 2 *b c d*). The surface of attachment must be very small, or else the granular covering prevails as much on that side as elsewhere: at any rate, we always find the whole cell, when loosened, covered by these granules.

The first feature that strikes the eye when investigating the interior of these lasso-cells is the total absence of the axial, rod-like body, so commonly observed in all other lasso-cells (see Pl. XIX. *Fig.* 5 *b b'*): the whole middle portion appears totally void, and such is the true state of things, for the coil always presses closely against the inner surface of the wall, as long as it is in a quiescent state. The wall has one uniform thickness throughout, excepting at one point, corresponding to one of the ends of the coiled thread, and there it thickens and forms a broad, conical basis, with which the lasso is continuous, the one gradually passing into the other (*Fig.* 2 *c*). Although the thread arises from the wall very obliquely, it is not attached by one side, but at the extreme tip, and suddenly bends upon itself to follow its spiral course. When partially uncoiled (*Fig.* 8), this sharp bend (*c*) may be more plainly seen; but when it is straightened out (*Figs.* 3, 4, 5, 10 *c*) the bend disappears, and the thread meets the wall at right angles. In this state the broadened base is a marked feature. Returning to the uncoiled lasso again (*Fig.* 2), we will observe that the coils (*b*) are set very far apart, but at equal distances, and do not make more than seven or eight turns before the thread terminates very abruptly, at a point (*d*) directly opposite to the basis of attachment (*c*); but the end is perfectly free from the wall against which it presses. Another noticeable feature in the thread is, that it is as easily seen at one part as at any other; and this is owing to the fact, that it has one uniform thickness from the base to the tip. This, when compared to the gracefully tapering lassos of Discophoræ (Pl. XV. and XIX. *Fig.* 5ᵃ), appears very clumsy, and looks as if it might be rather inefficient; yet nowhere do we find lassos so tenacious of their hold as among the Ctenophoræ: and this is all the more remarkable because, in addition to the shortness of the thread, which is only eight or nine times longer than the diameter of the cell, it is perfectly smooth, and also blunt at the tip.

With this amount of knowledge of the lasso-cell, one might very naturally suppose that the lasso makes its exit from the cell as all other lassos among Discophoræ

up within the cell, and knew nothing of the peculiar mode of connection between the thread and the vesicle: and both mistook the granular bodies to be *within* the cells, instead of *without*.

and Polypi have been known to do; that is, by turning inside out, and at the same time sliding through its own base, like the inversion or eversion of the finger of a glove, or the feelers of a snail: but nothing of the kind occurs. In the first place *the thread is solid*, and therefore demands a mode of extension correlative with this peculiarity, and a mode, too, which is typically different from the method by eversion. We must confess to having been completely taken by surprise when we discovered that part of the cell opposite to the base of attachment gaping wide open (*Figs.* 8, and 11 *c*), as if a segment of a sphere had been cut off, and the thread, more or less uncoiled, thrust out, directly from its point of attachment, freely into open space. Sometimes the thread was partially extended; but the aperture of the cell was closed around it (*Figs.* 6, 7, 9, 12), and, as in the first case, it was the free end of the lasso which projected. It might be supposed that the extension was effected by the contraction of the cell wall, or by pressure from surrounding parts, or from behind, were it not that the cell is seen to open widely, drawing back as if by means of retractor muscles, in order to let the lasso spring out, through the broad-spread aperture. No amount of compression can straighten out, or even partially extend, the thread; but this is evidently done by its own inherent power, the mouth of the cell simply gaping to let it pass. This must of necessity be the case, or how otherwise could the thread coil itself up and retreat into the cell, as we have seen hundreds, and we might say thousands of them do? At one time the tentacle was as if covered by short, curly hairs, and the next moment the little curls had disappeared, like magic. After the thread is out, the cell closes or remains wide open (*Figs.* 3, 4, 8), and contracts more or less upon itself, the wall thickening according to the amount of contraction.

After the foregoing description, it hardly need be remarked that the base by which these cells (*Fig.* 13 *b*) are attached to the subjacent outer wall (*c*) of the tentacle is the same side on which the lasso-thread has its connection (*Figs.* 1 to 12 *c*); and therefore the latter can never be wholly extruded, unless the vesicle turns inside out. The thickness of the lasso is not only uniform from base to tip, but it does not change either by extension or by contraction. There is much difference between the degree of consistency of the wall of the cell and the lasso-thread, as may be demonstrated by allowing decomposition to set in, when the wall will disappear altogether, before the thread shows the least sign of decay (*Fig.* 5). As to the manner of proceeding when these coils have arrested any foreign body, we have made no positive observations: we only know, that, as far as their tenacity of hold is concerned, they cling as pertinaciously to a smooth glass rod or a well-polished needle as to any other body; not by coiling the tentacle around them, but by simple adhesion of the thread itself; and this is the more remarkable, since the latter is not only short, but perfectly smooth, possessing none of those salient points, which, in more or less spiral lines, beset the lassos of the majority of Discophoræ.

In order to form a correct idea of the ever-changing state of the tentacular apparatus, it is necessary to keep in mind, not only the form and structure of all its parts, but also their relative position in different points of view, as represented in my paper in the Memoirs of the American Academy, Pls. III. and IV. The base of this apparatus being attached by its flat side to the inner wall of the cavity, appears in profile, in a front view of the animal, so that the flat disk is represented by a narrow margin, and its whole height is apparent. Seen from the sides of the animal its width becomes distinct, and the edges, encircling its margin and rising from the abactinal summit of the disk along its middle line to form the projecting base of the tentacle, are seen in front. Seen in half profile or in a three-quarter view, both margins and the tentacular base become distinct, and the tentacle which arises from the disk can be traced from its origin along the basal part of its course. In such views the whole height of the apparatus is equally apparent; but when seen from above or from below, the cavity of the tentacles and the tentacular apparatus itself are shortened, and the two chymiferous tubes along the inner wall of the disk appear like two holes. Correctly to appreciate the relations of the tentacle proper with the flat disk from which it arises, it is necessary further to keep distinctly in view the arrangement of the margin encircling the disk. Along the vertical chymiferous tubes which extend to near the actinal end of the tentacular cavity, there are, on each side, linear edges slightly swollen in their middle, and curved over the middle of the disk from the actinal side, where they unite (Pl. II[a]. *Fig.* 15); then extending again toward the abactinal side, they are detached from the outer surface of the disk, to meet on their abactinal margin a similar fold rising from that side, and then hang downward into the bottle-shaped cavity free, as an independent thread, surrounded as soon as it is free from the disk by numerous small elastic and contractile tentacles. The main thread, however, forms the stem of the tentacle, which is capable of extraordinary development, and can also be contracted into a coiled bundle; so that, in the state of utmost contraction, it forms a sort of irregular ball of tuberculated appearance hanging from the hook, the tubercles of the surface being the lateral fringes: but when elongated it is changed into a fine thread, and the fringes appear at intervals either in a contracted or elongated form, assuming in the former state the appearance of little tubercles, which in their elongated condition are themselves like so many little threads. Their arrangement near the base of the tentacle is not easily ascertained; but when expanded, or regularly contracted within moderate limits, it is evident that they all arise from one side of the main thread, and are throughout unilateral; and where one is occasionally seen in a different position, it is easily ascertained to be out of place, owing to some accidental pressure. The variations which they undergo in their various degrees of contraction and expansion having already been described when speaking of the movements of these animals, I need not refer to the subject again. I have only to add, that they appear frequently coiled up like a corkscrew, in a regular and more or less elongated spiral. But, strange to say, in this position, though placed upon the two sides of the body in a symmetrical position, the spiral is not antitropic, but coiled in the same direction on both sides of the body, though their bases and hooks, and, indeed, the whole upper part of their structure, shows a regular antitropic arrangement, like all symmetrical parts throughout the animal kingdom. Here, however, I have constantly found the spirals of the thread, when coiled up, curved in the same direction, both of them turning to the left in an ascending direction or to the right in the opposite direction. This is the more surprising, as in animals in which there are parts twisted upon the two sides of the body, those of the right side are curled in one direction, and those of the left side in the opposite direction, in order to establish perfect symmetry. Thus, the horns of cattle, sheep, and goats are twisted, the right to the left, and the left to the right; while in antelopes the direction is reversed, the right horn being twisted to the right and the left horn to the left. The same antitropy is also observed in the bend of the tusks in elephants and wild boars, or of the horns in deer, etc. Such an antagonism seems, therefore, not yet to prevail among Radiata, in which the anterior and posterior extremities have not become prominent.

The lateral fringes have the same structure as the main thread, consisting, in the middle, of a bundle of elongated cells surrounded by epithelial cells. When contracted, the longitudinal cells, extending into the main thread, appear like transverse fibres. There are, however, no transverse fibres proper in the main thread, any more than in the lateral fringes; as in every instance those transverse fibres of the main thread can be traced into the centre of the lateral ones. The extension of the threads must therefore be of a more passive character, owing to the relaxation of the fibres, and cannot be produced by the contraction of annular fibres; though the longitudinal cells of the lateral fringes may perhaps contribute by their contraction to the elongation of the main thread. This disposition explains very fully the slow elongation of the tentacles, in comparison with their quick and almost instantaneous contractions, and also the peculiar phenomenon attending this elongation, when, by starts, the main thread seems rather to be dropping from point to point to its fullest elongation in a passive way by the relaxation of the fibres. I am, however, at a loss to explain by their structure the elongation of the lateral threads at right angles with the main thread when this is fully expanded, and their various other dispositions, their frequent straight and apparently stiff elongation, and, still more, their sudden bending even in acute angles. These motions are so diversified, and sometimes so sudden, as to astonish even those familiar with the movements of these animals.

Having described above the position and changes of form of the digestive cavity, I have now only to add, that its inner surface has not throughout the same appearance, and is not uniformly flat. Near the aperture of the mouth, indeed, it is smooth; and, when the mouth is fully expanded, a broad funnel is opened, leading directly into the digestive cavity, assuming, however, in its contractions, very diversified forms, being at times perfectly circular, and at other times oblong, oval, or even angular. The anterior and posterior angles of the mouth form frequently a fold, or it assumes a linear shape, or a stellate form. The more the mouth is open and spread out, the more easy is it to follow to a considerable depth the tubes which extend vertically along the walls of the stomach or cœliac cavity. The walls of this cavity present four folds, two of which are in the direction of the fissure of the mouth, along the anterior and posterior walls of the stomach, and two others at right angles with them along the middle of its broader wall, in the plane of the transverse axis of the body. These four folds are lined with brown cells, suggesting the idea of a rudimentary liver, or, at least, that of secreting cells aiding in the process of digestion. Towards the abactinal extremity of the digestive sac, between those prominent folds, the walls of the digestive cavity are lined with a vibrating epithelium, which is particularly active round the abactinal opening of the sac, when this is fully open. This vibrating epithelium is continued upon the inner surface of the central chymiferous cavity, into which the stomach pours its contents.

If we now view this animal from the abactinal side, we find a variety of organs, the structure and connections of which are not easily understood. Considering them at first chiefly in their relations to one another, it will be seen that there is in that region an elongated area, well circumscribed in its outlines, extending in a longitudinal direction, in the same plane as the mouth, with a black speck in its centre (Pl. II^a. *Fig.* 20). Towards the centre of this area eight narrow bands are seen converging, and, in an oblique position to its axis, near the black speck, two slight projections may be observed near the margin of the area. The black speck in the centre rests upon a tubercle within, which is itself encircled by a fork of the funnel. This organ, which is considered as an eye-speck by some anatomists, and as an auditive sac by others, is a globular or broad pyriform mass (δ) of large, highly refractile cells or vesicular bodies, altogether enclosed in a large, exceedingly transparent, dome-like capsule (δ'). The pyriform mass (δ) is attached to the bottom of its capsule (δ') by its narrower end, and is constantly nodding or vibrating, whether by its own power or by the action of the vibratile cilia which line the capsule it is not possible to say, as we have never seen the cilia in a quiescent state. The narrow longitudinal area is a shallow furrow with a well-circumscribed and somewhat prominent margin. The irregular transverse bulbs at the base of its anterior and posterior halves, near the black speck, are the swollen extremities of two branches of the medial vertical funnel. Starting from these facts, we may perhaps throw some light upon the structure and functions of the whole structure. Let us, for this purpose, consider anew the funnel itself. We have seen that it is simply a central, vertical prolongation of the digestive cavity, tapering gradually into a narrow neck; but before it reaches the abactinal surface it enlarges again very suddenly, branching into two forks, which are themselves swollen into two irregular bulbs projecting towards the surface, one in front, and the other behind the central black speck, but both close to it and partly encircling the tubercle upon which the black speck rests. These two bulbs are therefore simple dilatations of the forked abactinal extremity of the funnel, and we constantly see undigested matters crowded in them and revolving in their cavity, with a tendency to accumulate laterally in an obliquely opposite direction in each of them. And at long intervals these prominent oblique angles will open outward, when the fœcal matter within the bulbs is discharged, the aperture remaining for a longer or shorter time extended, and the vibrating cilia lining the inner surface playing very actively; but after a little while these openings shut again.

These apertures might therefore be considered as a double anus; but I think it would be a very injudicious comparison to homologize them with the anus of higher animals, for in this type the process of digestion and assimilation and the circulation of the nutritive digested food are carried on by means of organs widely different from those of either Mollusca, Articulata, or Vertebrata. We have seen above, that the food is introduced into the digestive sac which occupies the centre of the spherosome; that this sac opens freely into the central chymiferous cavity, and discharges into it its contents, mixed with a large quantity of water; that this peculiar apparatus is subject to regular contractions, and circulates the fluid, with the nutritive parts suspended in it, into the various tubes branching through the whole system; and that gradually the refuse matters accumulate on the abactinal prolongation of the central vertical funnel, to be discharged through the openings of the two hollow bulbs branching from its extremity. We have here, therefore, rather openings in the circulatory system than anal apertures; or, rather, we have here an apparatus entirely different in its adaptation from either the alimentary canal or the circulatory system of higher animals, but constructed upon the same plan as similar organs in the class of Polypi and in other Acalephs, with only this difference,— that in Polypi the digestive central sac empties its contents into a large cavity subdivided only by partitions, without definite circulatory tubes, but along which the fluids are nevertheless circulated up and down and into the tentacles, and discharged either in a retrograde current through the stomach and mouth, or through the tentacles and lateral pores, when such exist. In Discoid Medusæ a similar circulation takes place, but without openings either in the periphery or opposite the mouth; here, the fluid accumulated in the digestive cavity is circulated through tubes into the periphery and around it, and the refuse matters, retracing their course, are emptied through the mouth. No Medusæ have peripheric openings of their chymiferous system through which the refuse matters may be discharged, as Ehrenberg maintains; but in all of them, as well as in Polypi, the whole digestive apparatus is in direct broad communication with the circulatory apparatus. The fluid circulated is simply chyme mixed with water, and carried to all parts through the chymiferous tubes. In Medusæ proper this fluid retraces its course, and may be discharged through the mouth. In some Polyps it is also discharged through the mouth only, while in others it may also find an outlet through the tip of the tentacles and through the lateral pores of the spherosome; but in Ctenophoræ it is discharged through the openings of the funnel. These animals never have a continuous alimentary canal with a simple anterior and posterior opening, nor a distinct circulatory system deriving its fluid through lymphatics from the alimentary cavity; but all have two closely connected systems broadly communicating with one another, through which alimentation takes place, one of which presides chiefly over the function of digestion, while the other circulates the whole mass of digested food—that is, chyme mixed with water—throughout the system. It is therefore proper, in describing these organs, to avoid any names which may suggest an identity with those of other animals with which they are only analogous. For this reason I have adopted the name of cœliac cavity for the digestive sac, and called funnel the central chymiferous cavity; and its branching tubes, chymiferous tubes or chymiferous vessels. The circulation which takes place in this system of tubes is not to be homologized with a blood circulation: it is only a chyme circulation, the fluid moving to and fro in opposite halves of the body by their alternate contractions.

If we next consider the oblong area, I must first correct a mistake I made in my paper upon Beroid Medusæ, in which I stated that the space circumscribed by its outline is a hollow space, extending forward and backward from the two cloacal bulbs, in a direct prolongation of the cavity of the bulbs. I must have been misled by an oblique view of the funnel, producing the appearance of a circulation in the area itself. The ridge which circumscribes this area is very definite, and, though smooth, slightly prominent upon the surface, so that the circumscribed area is really a broad, shallow depression, covered with superficial vibratile cilia. But in some Ctenophoræ, such as the true Beroids, this ridge is fringed; and the marked outline of the area in our Pleurobrachia is a rudimentary development of such fringes.

The narrow bands, alluded to in my first paper as tubes converging toward the centre of the circumscribed area, can be traced from the abactinal extremity of the vertical rows of locomotive flappers to the very base of the black speck in the centre of the abactinal pole of the body. These bands are not tubes, but a double or triple row of coarse, immovable cilia, or, more properly speaking, short, acute ridges, which trend in one direction in the same band. They are direct prolongations of the rows of locomotive flappers, tapering gradually toward the abactinal pole of the animal, and so reduced in their diameter as to appear like very slender threads converging from the abactinal termination of the locomotive flappers to the centre of the abactinal surface of the animal. They terminate under the eye capsule (*Fig.* 14 and 19 δ), and at the very base of the pyriform eye (δ). These bands are eight in number, like the ambulacral rows of which they are the continuation, and they converge two and two, being more closely brought together in pairs toward the eye-speck. In their respective position they differ somewhat: four of them, rising from the four lateral ambulacra, preserve a rather straight course from the summit of the rows of flappers to the centre of the area; the four others, the anterior and posterior ones, however, bend toward the elongated part of the area and follow obliquely the course of its margin, thus contrasting in some degree with the lateral ones.

I am somewhat at a loss to account for the precise connection between all the parts which may be seen around the central black speck (Pl. II^{a}. *Figs.* 14 and 19) and in the fork of the funnel. Even the nature of the central organ is in a measure problematical. In its appearance it resembles the marginal colored specks observed in Discoid Medusæ, and on that account has been viewed by some as an eye-speck; while by those who consider the so-called eye-specks of Medusæ as rudimentary auditory organs, it has been regarded as a rudimentary ear. But, notwithstanding the difference of opinion respecting its functions, all naturalists who have examined Ctenophoræ have thus far identified the black speck, which occurs in a central position upon the abactinal pole of these animals, with similar specks occurring about the periphery of Discoid Medusæ. The opinion I formerly entertained of the nature of this organ has been disproved by embryological researches. Since I have become acquainted with the development of the Ctenophoræ, I am myself satisfied that it cannot be considered as the remnant of a point of attachment to a Hydroid stock; for the Ctenophoræ undergo a direct metamorphosis. Nor do I now doubt its identity with the marginal specks of the higher Discophoræ; and I have already stated, that I am inclined to regard it as a Cyclopean formation, resulting from a central combination of the specks, which, in Discophoræ, occupy a peripheric position.

The nature of the tubercle, or ganglion-like mass, placed between the eye-capsule and the fork of the funnel, is still more problematical. This body is of larger size than the black speck and its capsule, under which converge the eight narrow prolongations of the ambulacral rows, and on the anterior and the posterior side of which are seen four smaller tubercles or swellings, between which arise two ridges rapidly diverging forward and backward. I can offer only suggestions respecting these parts. I am, however, inclined to believe that the two ridges between the four small swellings extending forward and backward are only outlines of the folds which form the circumscribed area; that the four small swellings themselves are clusters of cells connected with the narrow termination of the ambulacral rows; and that the wall-like outlines of the tubercle are determined by the fork of the funnel. As for nerves, which are said to arise from the ganglion connected with the black speck, I have been unable to make them out. I have traced the motory cells which surround the abactinal extremity of the chymiferous funnel; I have seen these cells diverging from the actinal side of the so-called ganglion, but have never been able to trace any one of them beyond the usual length of these cells; I have repeatedly seen these cells in a state of contraction or relaxation, presenting so little resemblance to nerves that I think it rather assuming to ascribe a nervous system to the Ctenophoræ. I am even satisfied, from the descriptions published, that the eight converging narrow prolongations of the ambulacral rows, of which I find no mention in former authors, must have been mistaken for nervous threads by some; and when Professor Grant states that Beroe has eight main nerves arising from eight ganglions, I suppose he alludes to some contracted cells of the spherosome, or to the eight narrow abactinal bands, the connection of which with the rows of locomotive flappers is so easily traced. I do not, however, deny that this centre is a point where we have to look for at least one part of the nervous system, and the movable margin of the mouth for the other part, if there really be a distinct nervous system in Ctenophoræ. But, as for myself, I have failed in tracing it out; though, I may add, I am sufficiently acquainted with the structure of the region where it is said to have been observed, to doubt the accuracy of the statements which have been made about it. And I express these doubts, notwithstanding the doubts I myself entertain respecting the real nature of some organs around the central black speck, for the very reason, that, after finding there more than has been seen and described, and various things which may answer the vague descriptions given, I do not in reality find what has been said to exist in that part of the animal.

When I first described our Pleurobrachia I did not know its mode of development; but, during the latter part of the summer of 1858, I had ample opportunities of tracing it through all its stages, and am now engaged upon a comparative study of its embryology with that of Bolina and Idyia, which have appeared in unusual abundance this summer. I will therefore postpone the publication of my earlier observations until the more recent ones are completed, and, in order not longer to delay the printing of this volume, pass them over here, and simply state, that before the young has reached one twenty-fifth of an inch in diameter, it has already assumed the appearance of the adult, while in its earlier stages it presents the greatest uniformity in the three types which came under my observation. The sexual organs have the same typical structure as in the other Ctenophoræ, but they are only distinctly visible when the spawning season approaches, late in the summer.

Having recently seen myriads of these animals, it may not be superfluous to add, that all the various attitudes in which I have formerly seen them in confinement may be observed at one glance, when coming suddenly upon a bank of them slowly drifting with the tide. Under these circumstances, however, they are not altogether at the mercy of the current; and it is curious to see how they resist its action by stretching their tentacles in a straight line in opposite directions and at right angles with the vertical axis of the body. I have also satisfied myself that they are aware of the approach of danger; for day after day I have seen thousands of them, which were quietly moving near the surface with the mouth wide open in search of food, suddenly turn upon themselves and with a quick jerk dive into the deep as my boat drew nearer and nearer. In fact, all Acalephs dive away from the surface when approached, and make accelerated motions to escape the net or glass dipped into the water to catch them. It seems as if they were endowed with the power of seeing, for noise has no effect upon them.

In conclusion, I would mention the most prominent specific characters of our Pleurobrachia. It is the smallest of the genus; of remarkable transparency and throughout hyaline, with a flesh-colored lining of the cœliac cavity, turning to brown at its abactinal end and shining through the body; the tentacles are throughout rose colored, the main thread as well as the lateral threads; the rows of locomotive flappers rather milk-white and iridescent. Inhabits the coasts of New England and Canada, where it is seen through the whole summer. Spawns in August and September.

SECTION II.

THE GENUS BOLINA AND ITS SPECIES; WITH REMARKS ON ALLIED GENERA.

The genus Bolina was first described by Mertens, from two species observed in the Pacific and in Behring Strait.[1] It is considered as differing from other genera of Ctenophoræ by the great development of the mantle lobes, and by the circumstance of its eight rows of locomotive flappers not extending beyond the body itself; and though this characteristic is not strictly correct in as far as I shall be able to show that the ambulacral rows are not strictly circumscribed within their apparent limits, the genus itself is a very natural group, which ought to be generally acknowledged. I have already stated (page 201), that the genus Bolina differs so far from Mnemia as to constitute a distinct family, the lobes of the spherosome being only actinal prolongations of the anterior and posterior spheromeres, while in Mnemia and Alcinoe they arise as lateral folds between the lateral and the anterior and posterior spheromeres. I have also pointed out generic differences between Bolina elegans *Mert.* and Bolina septentrionalis *Mert.*, which will require their separation; but I would retain the name of Bolina for the type to which B. septentrionalis *Mert.*, our B. alata, and Sars's Mnemia norvegica belong. It is difficult to give a correct idea of the form of these animals, as they assume most diversified aspects in their various movements, and in the different attitudes in which they have to be considered. Having had ample opportunities repeatedly and for a longer time to examine a new species of this genus which I have kept alive, at intervals, for months, I shall attempt to give a more complete idea of its remarkable structure, which may throw some new light upon the organization of the whole family, and also upon the natural relations which exist between its different genera. I saw this new animal for the first time with Mrs. Arnold, of New Bedford, who had preserved it alive for my examination, in December, 1848. I myself afterwards found large numbers of specimens during the months of March and April, and even as late as June, in various parts of Boston Bay. I now know that it may be found through the whole summer, not only along the coast of Massachusetts and Maine, but even as far north as Labrador. Dr. A. A. Gould, however, had already noticed this species as an inhabitant of the shores of Massa-

[1] This genus is characterized in a remarkable paper by Mertens on Beroid Medusæ, published in the Transactions of the Imperial Academy of Sciences, in St. Petersburg, in the second volume of the sixth series, 1833. The species described are chiefly from the Pacific.

chusetts, in his Report on the Invertebrated Animals of that State, where he considers it, however, as identical with the Alcinoe vermicularis of the coast of Brazil. But a close examination has satisfied me, that it is neither identical with that species, nor even belongs to the genus Alcinoe, but constitutes the first Atlantic representative of the genus Bolina.[1]

There is a marked difference between this species and Bolina septentrionalis *Mert.*, in the less limited development of its longitudinal diameter, in the greater approximation of the two auricles of each side, and in the greater width of the large lobes; for which reason I have called our species Bolina alata. Like all true Bolinæ, it is of a transparent bluish white. Bolina norvegica, Sars's Mnemia norvegica, is at once distinguished from the species found along the north-west and the north-eastern coast of America, by the sudden projection of its lobes. A fourth species, which I call Bolina vitrea, occurs on the southern coast of Florida. It differs from the preceding ones by its greater height, the narrowness of its locomotive flappers, and its extraordinary transparency. I am unable to state with certainty, whether Bolina hybernica *Patt.* differs from the species described by Sars or not.

Bolina alata is a most delicate, transparent, and diffluent animal; so soft that it readily decomposes under the least unfavorable circumstances. The admixture of a small proportion of fresh water in the bowls in which I used to preserve them caused not only their immediate death, but also their instantaneous decomposition. All my efforts at preserving specimens in Goadby's liquor have entirely failed; and when, under identical circumstances, I succeeded in keeping for a long time specimens of Pleurobrachia rhododactyla, I failed in preserving specimens of Bolina alata longer than twenty-four hours. Again, this species being by no means so common as the Pleurobrachia, with which it is always found associated, I had to contend with great difficulties in my investigations of its structure. I succeeded several times, nevertheless, in injecting it with indigo; and, though the injection soon caused the death of the animal and its decomposition, I have been able to trace

[1] It is a remarkable circumstance, that the Atlantic shores of America should furnish, in lower latitudes, a species of the genus Bolina very similar to that which occurs in Behring Strait; but this is only one of the many instances showing that species on the opposite shores of this continent are adapted to the differences which exist in the climatic conditions, and the different course of the isothermal lines on the eastern and western sides of the Old and New Worlds. It is also interesting to notice, that while Bolina alata is, everywhere on our coast, found associated with Pleurobrachia rhododactyla, another species of the genus, described as Mnemia norvegica by Sars, accompanies the Pleurobrachia bicolor of the boreal fauna of Europe; and that the Bolina septentrionalis of Mertens belongs to the same fauna with the Pleurobrachia Bachei discovered by my son in the Gulf of Georgia, where it occurs together with Bolina septentrionalis. Moreover, a distinct species of Idyia is also found in each of these three faunæ, one of which is described by Sars in his "Beskrivelser," and the other two in the following section of this chapter.

the circulation for a sufficient time to follow the entire course of the chymiferous fluids within the body, throughout all its parts. Besides, being already minutely acquainted with the arrangement of the chymiferous tubes in Pleurobrachia, I was fully prepared to institute a minute comparison between the two genera, to ascertain their differences, and to recognize the homology of their structure. I was even able to trace the connection of all the parts of the chymiferous system so fully in Bolina that I could ascertain the natural connections between all its peripheric tubes and the central chymiferous cavity, as well as the peripheric anastomoses of the tubes themselves. Such anastomoses are entirely wanting in Pleurobrachia, in which the ambulacral tubes end in blind sacs, on the actinal as well as the abactinal side of the body. Milne-Edwards presses too far the typical identity of the chymiferous system in Ctenophoræ. Had he perceived that these Acalephs, instead of forming one natural family, constitute four sub-orders with many distinct families, he would, no doubt, have given more weight to the differences which he himself has observed in their chymiferous system, and of which he makes too light.

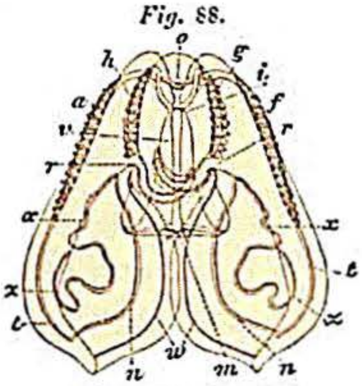
In order fully to understand the structure of Bolina alata,[1] and the relations of its various parts, it is necessary first to have a precise idea of its external form, which it is by no means easy to acquire, even after repeated investigations. Like Pleurobrachia, the body of Bolina is more or less ovate, but in an inverse direction; for its greater diameter follows the plane of the corresponding organs in such a connection as to show that the antero-posterior diameter is the longer, while it is the shorter in Pleurobrachia, and *vice versâ* that the transverse diameter is the shorter, while it is the greater in Pleurobrachia. This inverse agreement between the natural relations of the organs and the external form is most satisfactorily ascertained, upon comparing the position and direction of the circumscribed area and of the tentacles; and we shall hereafter see that the proportions of the body with reference to their longitudinal and transverse development are in every respect reversed in the two genera. Before this contrast had been established, I was unable to trace the homology of parts between the two genera. Indeed, taking the general form as a guide, I began by comparing the two animals in a position in which I undertook to place their prominent diameters in the same relation, and thus arrived at the conclusion, that the tentacles of Bolina, which are far less developed and issue from the margin of the mouth itself, were organs entirely different from the tentacles of Pleurobrachia. The latter I considered as a system peculiar to this type of Ctenophoræ, because they are protruded from the sides of the body; while the tentacles of the type of Bolina appeared to me as a sort of fringes

[1] As I have published numerous views of this animal, in different attitudes, in my paper on Beroid Medusæ, printed in the Memoirs of the American Academy, I would refer to them for further comparisons, having only reproduced a few of them in the wood-cuts of the following pages.

of the mouth. But the moment I placed the diameters of the two bodies in a position inverse to their length, all parts being placed in the same natural relation as far as they correspond by structure, their perfect homology, throughout the system, was at once established. And not only the correspondence and antagonism between the abactinal area and the tentacles, but also the minor details in the ramifications of the chymiferous system, agreed in every respect. The difficulty under which I had labored was precisely that of an artist attempting in a family picture to bring out the resemblance between two kindred faces, while contemplating one individual in profile and the other in a front view, but believing their position to be the same. With this inverse relation between the homologous parts, considered in their reference to form in the two genera Bolina and Pleurobrachia, there is a corresponding opposition between the natural positions of the two animals in the surrounding medium. Pleurobrachia, as I have stated, swims naturally with the mouth upward or forward, and the circumscribed area downward or backward; Bolina moves with the mouth downward and the abactinal area upward.

The position of the tentacles, their natural relations to the body when in motion, and the direction of the aperture through which they issue, were the chief sources of error which led me at first to consider them as different organs; for in Pleurobrachia (Pl. II[a]. *Figs.* 22, 23, and 25) they are turned toward the cœliac apertures, while in Bolina (*Figs.* 88 and 89 *m*) they are turned toward the oral aperture. But now we may ascertain the homological identity of these appendages, by placing these two animals in their normal position, instead of viewing them in their natural attitudes. And it will be easy to understand how, in accordance with the form and movements of the various members of the whole family, the tentacles may issue from different heights of the vertical diameter upon the sides of the body, and, according to the direction of its movements, be bent either toward the mouth or toward the cœliac apertures. Judging from Pleurobrachia and Mertensia when contrasted with Bolina and Euramphæa, we might infer that the

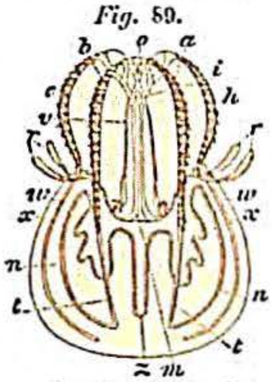
Fig. 88.



BOLINA ALATA, Ag.
(Seen from the broad side.)

a and *f* Long rows of locomotive fringes. — *g* and *h* Short rows of locomotive fringes. — *o* Central black speck (eye-speck). — *i* to *m* Triangular digestive cavity. — *i* to *o* Funnel-like prolongation of the main cavity. — *r* Chymiferous tube of the tentacular apparatus. — *m* Tentacular apparatus on the side of the mouth. — *r r* Ear-like lobes, or auricles, in the prolongation of the short rows of locomotive fringes. — *t t* Prolongation of the vertical chymiferous tubes. — *n n* The same tubes turning upwards. — *x x* Bend of the same tubes. — *z z* Extremity of the same tubes meeting with those of the opposite side. — *w* Recurrent tube anastomozing with those of the auricles.

Fig. 89.



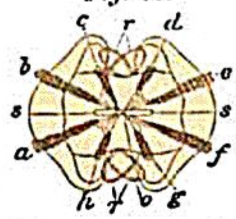
BOLINA ALATA, Ag.
(Seen from the narrow side.)

a b Long rows of locomotive fringes. — *c h* Short rows of locomotive fringes. — *o* Central black speck (eye-speck). — *i* Upper end of the digestive cavity. — *i* to *o* Funnel-like prolongation of the main cavity of the body. — *m* to *i* Digestive cavity. — *r r* Auricles. — *m* Mouth. — *t t* Prolongation of the vertical chymiferous tubes. — *n n* The same turning upwards. — *x x* Bend of the same tubes. — *z* Anastomosis of the two longitudinal tubes *t t*. — *w w* Recurrent tube, anastomozing with those of the auricles. — A comparison of this figure with *Fig.* 88 gives a distinct idea of the relative position of the digestive cavity, *m* to *i*, and the chymiferous tubes of the tentacular apparatus *r*.

tentacles are more and more developed in proportion as they are further removed from the mouth. But Leucothea shows that oral tentacles may be as extensively developed as those which issue from the sides of the body. That the tentacles of the Ctenophoræ cannot be homologized with either the tentacles around the mouth, or those around the disk, of Discoid Medusæ, has already been shown.

After this digression, if we return to a more direct consideration of the form of Bolina, we find that it differs from Pleurobrachia in the extraordinary development of two lobes in the actinal prolongation of the anterior and posterior spheromeres (*Figs.* 88, and 89 *z t n x*), inclosing, when shut, the mouth and its appendages, each lobe extending transversely to the antero-posterior diameter, one forward and the other backward; so that they contribute, when expanded, to increase the already prominent length of the longitudinal diameter, leaving a deep, transverse chasm between them, at the bottom and centre of which the mouth (*Fig.* 88 *m*) is situated. The body thus shuts up by the alternate approximation and separation of two valve-like lobes, hanging downward, and placed, one in front and the other behind the spherosome, in a position precisely inverse to that of the valves of Acephala, which rest upon the sides of the body, and move laterally. In addition to these two large, broad lobes, there are on each side two smaller lobes (*r r*), the auricles, which arise from the body at about the same height as the anterior and posterior lobes. They are simple, short, narrow appendages, converging or diverging alternately, and thus shutting from the side and above the great transverse fissure of the animal. With the power which these animals enjoy of opening widely or shutting closely the anterior and posterior lobes by contraction and dilatation, and thus bringing them alternately close together or stretching them far forward and backward, their general appearance is constantly so completely changing that it requires a long acquaintance with them fully to appreciate the connection of all their parts in their different attitudes, and the influence of the movements of certain parts upon the position of others and upon their functions. The activity of the circulation through the chymiferous tubes, and the position the main branches of the central cavity assume during these changes, are constantly modified, as are also the width of the body and the power of its contractions. And, in the same proportion that the extent of the longitudinal diameter is modified by the expansion and contraction of the anterior and posterior lobes, the height of the animal, compared to its width and length, is also constantly changing. If we add to this the diversity of images which are brought before us when we watch these animals in their various movements from different sides, facing alternately the longer or the shorter diameter, the sides or the actinal and the abactinal areas, I venture to say, that it is impossible to make correct descriptions and to give true representations of such animals, unless they have been watched for a long time in a living state; for it is out of the question to examine their forms out of the water, as all parts then collapse, fall together, break to pieces, or dissolve into a shapeless mass. And, although I acknowledge the great interest of the descriptions published by travelling naturalists, making us acquainted with the extensive diversity of types of these remarkable animals all over the world, satisfactory illustrations cannot be expected from any quarters, save those where able observers have resided for a longer time. The accounts of the generic and specific characters of most Medusæ must therefore be considered as provisional, so long as they are not revised under favorable circumstances.

Fig. 90.

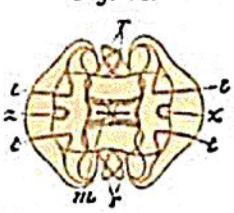


BOLINA ALATA, Ag.
(Seen from above.)

o Central black speck (eye-speck). — *a b e f* Long rows of locomotive flappers. — *c d g h* Short rows of locomotive flappers. — *r r* Auricles. — *s s* Circumscribed area of the abactinal end of the body.

Viewed from the abactinal side, with the lobes contracted, Bolina appears very much like Pleurobrachia, assuming then the form of a slightly compressed sphere (*Fig.* 90); and were it not for the fact that the circumscribed area runs in the longer diameter, while it is transverse to it in Pleurobrachia (Pl. IIa *Fig.* 20), the identity would be almost perfect. Seen from the actinal side, however (*Fig.* 91), even when the lobes are contracted, the difference from Pleurobrachia (Pl. IIa. *Fig.* 21) is already marked, owing to the circumstance that the vertical rows of locomotive flappers do not extend uniformly from one extremity of the animal to the other, the two ambulacra of the anterior and posterior lobes being much longer than those of the sides, which terminate at about half the height of the body.

Fig. 91.



BOLINA ALATA, Ag.
(Seen from below.)

m Mouth. — *r r* Auricles. — *t t t t* Prolongation of the long vertical chymiferous tubes. — *z z* Anastomosis of these tubes.

Viewed from the abactinal side with slightly opened lobes, the difference between the longitudinal and the transverse diameter is already more marked; but the four lateral lobes, or auricles, appear as appendages to the anterior and posterior lobes. However, as the larger lobes expand more and more, the small lateral lobes appear detached from them, and their real connection with the sides of the main body begins to be noticeable; and the greater length of the anterior and posterior ambulacra and the shortness of the lateral ones are quite apparent. In proportion as the anterior and posterior lobes are more and more stretched forward and backward, their edges assume a more pointed form, similar to the horns of a crescent, or rather to the blade of a tomahawk, and the whole body may be compared to two tomahawks in miniature, placed head to head in opposite symmetrical directions, the four short lateral appendages looking like two small sticks projecting like short handles through the eyes of the two heads for an equal length on both sides. Seen from the actinal side in the same development of all parts, the general outlines do not differ materially from the view just described, excepting that the mouth is in sight in the centre, extending forward and backward in the same plane as the circumscribed area opposite, and the ambulacra appear only indistinctly through the mass. The body is sometimes stretched to so great a degree in the direction of the longitudinal diameter, as to give its outline an irregular, square, oblong form. However, this attitude is only assumed when the animal swims at the surface of the water, with the mouth turned upward.

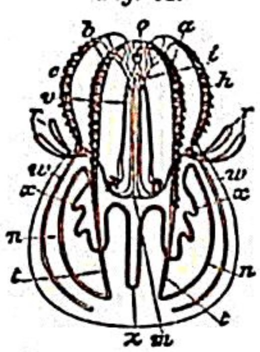
Viewed in profile, the body presents also two very distinct aspects: when seen by the broad face or by the narrow face, or when examined from its anterior or posterior or from its lateral sides. Facing the anterior or posterior end, the symmetry of the outline (*Fig.* 89) arises from the parity and symmetry of the right and left halves of the body, the two sides of the anterior and posterior lobes being perfectly symmetrical. But here again the outlines may differ greatly, in consequence of the expansion or contraction of the lobes, which may hang down and look almost straight with the main mass of the body above, or spread laterally and assume a rounded form, like a broad apron suspended from the chest with projecting auricles or appendages about its point of insertion. In this position the anterior or posterior pairs of ambulacra are seen in their fullest development, extending from the summit along the middle of the lobe to its lower margin, tapering gradually as the lobes grow thinner. Seen from the sides (*Fig.* 88), the symmetry of the outline arises from the perfect symmetry and equality between the anterior and the posterior extremity of the body; but the outlines may vary as the two lobes are pressed nearer together, or stretched apart to a greater or less extent. The modifications in this respect are almost endless, as also are the ways in which the margins of the lobes fold over; for their lower margin may hang loosely down, or it may bend inward, curving itself in rounded or square outlines, and reaching also over the sides or stretching more flatly. In these various states of dilatation or contraction, the lobes may diverge from each other in all possible degrees: one may even overlap the other alternately, and thus reduce to the utmost the difference between the longitudinal and the transverse axis. The small lateral lobes, two in number on each side, may, in these various changes of form, assume also the most diversified positions, — at times stretching straight downward, at times arching upward, at times hanging down and converging toward, and even crossing each other; so that there is no end to the diversity of these aspects. I should say, however, that the motions of these lobes, especially those of the two large anterior and posterior lobes, are comparatively very slow and graceful; while those of the small lateral lobes are somewhat more brisk.

Seen from the sides, the two lateral ambulacra converge from the abactinal area toward the base of the lateral lobes, and the anterior and posterior ambulacra of the same side appear in profile near the anterior and posterior margin, encircling in parallel curves the lateral ambulacra, but extending and gradually tapering all the way down to the margin of the lobes.

Our Bolina progresses rather slowly, its movements being tremulous, like dancing in slow steps through the water, and now and then revolving upon itself. It never performs those quick, darting motions which characterize Pleurobrachia, nor does it exhibit any thing like the graceful curves of the tentacles following like a comet's tail in the wake of Pleurobrachia; for in Bolina the tentacles do not extend beyond the margin of the lobes. And the lobes themselves, though the principal organs of locomotion, are an impediment to quick and graceful movements, the anterior and posterior ones being disproportionate in comparison to the size of the body. There is, however, one attitude in which the movements of this animal are exceedingly graceful: it is when the lateral lobes are fully expanded, and even recurved forward and backward, and so elongated as to appear like the petals of a flower spreading in opposite directions and curving outward. In this development the animal generally reverses its position, the mouth being turned upward, and the lateral lobes, also curved outward, present their vibrating fringes in the utmost degree of activity, — the whole animal resembling an open white flower, with two large and four small petals, revolving slowly upon its peduncle, or changing its place in various directions.

The ambulacra are so closely connected with the general appearance and the movements of our Bolina, that it is appropriate to consider them in this relation first. As in all Ctenophoræ, they consist of vertical rows of locomotive flappers, in every respect identical in their structure with those of Pleurobrachia, the difference consisting mainly in their extent. The pairs which run along the anterior and the posterior sides of the body and extend upon the two large lobes, are by far the longest, and also somewhat wider, their flapping combs tapering gradually toward the abactinal area, so that the ambulacral rows terminate in points at some distance from the central black speck. This is equally the case with the two lateral pairs of locomotive flappers, which, however, extend somewhat farther towards the centre of the abactinal area. The tips of these eight rows of flappers encircle the circumscribed area, which, however, extends far beyond, forward and backward, between the rows of combs of the anterior and posterior pairs of ambulacra. Another distinctive peculiarity of Bolina consists in the form of this side of the body, which is not uniformly rounded, as in Pleurobrachia, but somewhat depressed along the longitudinal axis; so much so that the two sides bulge sensibly above the level of the central speck, while the anterior and posterior spheromeres are on a level with it. The consequence of this prominence of the sides is that the abactinal extremities of the anterior and posterior rows of locomotive flappers run almost straight to their termination, while those of the lateral ambulacra are arched over the two rounded parallel ridges which inclose the circumscribed area. It is easily ascertained, that eight narrow bands, similar to those observed in Pleurobrachia, extend beyond the extremity of the ambulacra toward the central black speck, or rather toward the bulb under it, and that they are the prolongation of the vertical rows of locomotive flappers. Along the sides of the body the rows of locomotive flappers also gradually taper toward their actinal extremity, and, as soon as they reach the height of the dilatation of the lobes, the locomotive combs disappear, and the chymiferous tubes which accompany them can alone be traced farther. In the lateral ambulacra, however, the rows of locomotive flappers taper much sooner, and terminate at the base of the small lateral lobes, near their inner margin, for a considerable length above the actinal extremity of the ambulacra of the large lobes. In the small lobes we trace also a narrow prolongation of the chymiferous tubes of the lateral ambulacra, which extend beyond the locomotive fringes. The course of these narrow tubes in the lobes is very difficult to follow, and their connection with each other and with the central chymiferous cavity has been entirely overlooked by former observers, with the exception of Milne-Edwards;[1] though in the figures of Bolina elegans published by Mertens, there are already indications that he noticed the outline of their convolutions. I shall first trace the course of these tubes upon the larger lobes. As long as the tubes follow a straight course in the prolongation of the anterior and posterior ambulacra (*Fig.* 92 *t*), they remain at the surface of the lobes, covered only by the epidermis, beyond the ambulacral rows themselves. But as soon as they converge towards the lower margin, where they bend to take an inward course, they penetrate deeper into the substance, across the whole thickness of the lobe itself, till they reappear upon its inner surface, where they are nearest to each other; they then rise again, diverging toward the sides and following almost exactly the outline of the lateral margins of the lobes, along which they ascend (*n*) toward their bases, rising even higher than the lower termination of the ambulacral combs, indeed nearly as high as the bases of the auricles; they then converge again, bend downward, and in a sinuous, winding course (*x*) descend a second time toward the middle of the lobe, to rise and converge again, and then descend for the third time, in a parallel course, to nearly the same level with their first bend, and, converging once more from the two sides, unite (*z*) in the medial line of the lobe: so that there is a direct communication

Fig. 92.



BOLINA ALATA, Ag.
(Seen from the narrow side.)

[1] MILNE-EDWARDS, Recherches, etc. Ann. Sc. Nat. 2de sér., vol. 16, p. 203, Pl. 3.

between the right and the left ambulacral tube of the anterior and posterior pairs, passing in their course from the margin of the outer surface to the middle of the inner surface, first descending, then rising, then descending again in undulating lines, then rising and descending again, until they meet to form an anastomose in the lower central part of the lobe. Such a connection between any of the tubes on the oral side of the body does not exist in Pleurobrachia. Besides the meandering tubes of the long ambulacra, there may be seen, all over the inner surface of the large lobes, a curious network of angular meshes, resembling small vessels and connected with one another in a way which recalls somewhat the branchial vessels of the Naiades, though their arrangement is less regular and not so strictly rectilinear and parallel. When I first noticed these meshes I mistook them for real vessels, and have so described them in my paper on Beroid Medusæ; but I have recently ascertained that they are simply the outlines of the gigantic polygonal cells which form the inner layer of the large lobes. The ends of these cells are flattened against the inner surface of the lobes and covered by small epithelial cells, crowded in rows in the intervals or upon the outline of the large cells. A similar network exists also in Leucothea formosa, Alcinoe rosea, and Bolina septentrionalis, judging from the drawings of Mertens. Will has described the same thing in Chiaja;[1] but Milne-Edwards makes no allusion to it. Like Leuckart, Forbes, and Milne-Edwards, I have seen nothing in Ctenophoræ answering to the so-called blood-vessels described and figured by Will.

The ambulacra of the sides are reduced to simple chymiferous tubes as soon as they reach the base of the small lobes, whence the tubes continue in a very complicated course through these lobes, and then toward the mouth, sending also a branch to the large lobes. Each tube first follows the inner margin of its small lobe, then turns round the obtuse point of the lobe and retraces its course along the outer margin of the same lobe to its very base; here it branches in such a way as to unite simultaneously with a tube extending along the margin of the mouth, and with the marginal tube of the inner surface of the large lobes: or, it may rather be said, an anastomosis is established at the base of the small lobes, on their external margin, with a recurrent tube (*Figs.* 88 and 89 *w*) trending along the outer margin of the large lobes, as well as with another tube rising from the margin of the mouth. *Fig.* 3 of Pl. VII. of my paper in the Memoirs of the American Academy, in which the inner surface of the large lobes is turned outward for the whole extent of their margin, shows these connections most distinctly.[2]

[1] WILL, Horæ Tergestinæ, p. 55, Pl. I. *Fig.* 14, considers these meshes as forming part of the skin, and describes them as similar in structure to the tentacular threads.

[2] The letter-press mentions also distinctly these anastomoses, (p. 358). I am therefore surprised that Milne-Edwards should state that I have failed to notice the connection of the "canaux costaux laté-

The anastomosis with the large lobe is established through a tube which arises from the lower sinuosities of the inner convolutions of the long ambulacral tube. The communication with the oral tube is more direct, and may be considered as a branch from the tube of the short ambulacra: indeed, both may be considered so, the anastomosis with the large lobe, as well as that with the mouth. But, in the first case, the communication with the tube of the long ambulacra is more indirect; while the connection with the oral system is direct, through a tube which only bends at right angles upon itself.

The large lobes and the auricles are not identical in their structure, though homologous with one another. Each large lobe is formed of the actinal prolongation of two united spheromeres, while each of the small lobes or auricles is an actinal prolongation of a distinct spheromere. Moreover, the large lobes are bulky and thick, consisting of a large mass of the same kind of large cells of which the whole body is built; while the small lobes are simply membraneous, or rather diverticula arising from a folding of the surface of the body at the lower extremity of the short ambulacra, in the shape of flat sacs with hollow margins. They are, indeed, a mere fold in the direct prolongation of the short ambulacra, along the margin of which the ambulacral tubes and the locomotive flappers are continued all round the lobe; when the fringes disappear and the tube alone is continued, branching into the adjoining large lobe, as well as towards the margin of the mouth. We may therefore view the small lobes simply as modifications of the lateral ambulacra, rising above the general surface of the body and bent inward in proportion as the great transverse chasm which separates the two large lobes rises higher along the sides of the mouth, thus leading to the formation of a loop in the lateral ambulacra, instead of a straight course, as on the sides. The vibrating fringes of the small lobes are in direct continuation of the locomotive combs of the ambulacra proper, which would appear as long on this side of the body, and even longer, than upon the anterior and posterior spheromeres, if they were stretched in the same manner; but, being here folded over in the shape of prominent auricles, they act more energetically as lateral oars. There is, however, one marked difference between the ambulacral rows of locomotive fringes and their continuation along the margin of the auricles. As far as the locomotive flappers follow a straight course along the vertical ambulacra, their combs are transverse to the chymiferous tubes; but as soon as the tubes diverge sideways to follow the margin of the auricles, the locomotive flappers assume a longitudinal arrange-

raux" (the ambulacral tubes of the large lobes) with the "vaisseaux périgastriques inférieurs" (the cœliac tubes). What I did not observe was a connection between the ambulacral tubes of Pleurobrachia and its cœliac tubes (p. 357), which really does not exist.

ment, that is to say, they form a crest projecting outward along the tube. If this view of the small lobes is correct, we may consider the vertical branch or fork of the chymiferous tube, which extends beyond the auricles toward the corners of the mouth, as the direct prolongation of the ambulacral tube proper, and the fork which diverges into the large lobes as the anastomotic fork connecting the ambulacral tubes all round the body. The horizontal branches along the sides of the mouth should then be considered as the anastomotic branches between the two lateral ambulacral tubes of each side, and thus the circle would be made perfect.

With these facts respecting the structure of our Bolina before us, we are prepared to take another and not less instructive view of its peculiar symmetry, which may lead to a fuller insight into the characteristic features of Radiata. Not only are the two anterior and the two posterior spheromeres different in their development from the two lateral pairs, but they stand also in peculiar antitropic relations to one another. In the first place, the large lobes, each considered as a whole, are antitropic to one another, that is to say, they bend in opposite directions toward the vertical axis; and every point of the symmetry presented in a lateral view of the animal arises from this even balance of the anterior and posterior parts of the body, as seen in *Fig.* 88. But each lobe again consists of antitropic halves; or, in other words, the two spheromeres which form one lobe are as truly antitropic to one another as the two lobes themselves, for the outlines of the lobes as well as the course of their chymiferous tubes are evenly balanced, as *Fig.* 89 shows. The same is true of the lateral spheromeres: for here those of the same side, as seen in *Fig.* 88, are antitropic to one another, not only in their general outline, but more especially in the relative position and antagonistic movements of the auricles; and yet these adjoining spheromeres do not form a pair together, but stand again in antitropic relation to the lateral spheromeres of the opposite side, as *Fig.* 90 may show. Such a symmetry exists nowhere among bilateral animals, and appears to me one of the most striking peculiarities of the Radiates. Again, the opposite poles of the vertical axis exhibit the most striking contrasts, both in their differences and their antitropy, for the spheromeres converge as well toward the actinal as toward the abactinal area, though the two are occupied by different organs, or by identical parts unequally developed. A comparison of *Figs.* 90 and 91 may show at a glance the correspondence and the difference.

There is a great interest connected with a further investigation of the vibrating cilia of the small lobes, in comparison with the locomotive combs of the ambulacra. The former being very similar to common vibratile cilia, and the latter forming a more complicated system of locomotive organs, while both are morphologically fully homologous, it follows, that, in a series of structural complications, the locomotive flappers of the Ctenophoræ, in which each fringe is a whole cell, do not necessarily appear as a specific type of structure, but may constitute a natural link between more complicated organs with distinct muscles and the simplest fringes of structural cells. I entertain now so little doubt respecting such transitions, that I have not hesitated, throughout this description, to consider the rows of vertical locomotive fringes as true ambulacra; though there is as great a difference between them and the ambulacra of Echinoderms, as there is between them and simple vibratory cilia. We are, in fact, led to recognize, through the whole type of Radiata, a natural gradation in the structure of the organs through which currents of water are produced around the body, from the simplest combinations in Polypi to the most complicated apparatus in Echinoderms. In Polypi we have only vibratile cilia arising from structural cells over extensive surfaces of the whole body, while in Beroid Medusæ there are, in addition to such cilia, peculiar rows of fringes, made up of special cells, which move by their own contraction, and in Echinoderms each fringe, in the shape of an independent ambulacral tube, assumes as great a structural complication as the whole system in Acalephæ. The ambulacral tubes in Echinoderms generally, indeed, seem to me to bear the same relation to the aquiferous system with its vesicles in Star-fishes, and to the true ambulacral gills in Echini, as the fringes of the locomotive combs with their contractile base bear to the ambulacral chymiferous tubes in Ctenophoræ.

If, from this review of the superficial ramifications of the chymiferous tubes, we proceed to an investigation of their connection with the internal stems and the central cavity of the whole system, we find a very close resemblance in their arrangement to what has already been noticed in the genus Pleurobrachia, — the chief difference between the two genera consisting in the peculiar termination and connections of these tubes in the lobes of Bolina. The centre of the chymiferous system constitutes in Bolina, as in Pleurobrachia, a vertical hollow axis, extending from the centre of the abactinal area to the abactinal opening of the digestive cavity, upon the sides of which it gives off two cœliac tubes extending as far as the mouth. These tubes, however, are not so wide as in Pleurobrachia, while the digestive cavity itself is larger, extending nearer the central black speck; so that the funnel, which branches toward the circumscribed area, as in Pleurobrachia, is shorter, the main cavity from which the main trunks to the ambulacra arise much narrower, and the tubes extending toward the margin of the mouth along the lateral walls of the digestive cavity in the same proportion longer. But the general arrangement is identical. The differences exist only in the proportional development of the different parts of the whole system, as also in the curve of the main trunks of the ambulacral branches, which are more strongly bent upward, instead of stretching horizontally across the body. Owing to the lesser development of the central cavity of this system, and the difficulty of preserving these animals alive after injecting colored liquid into the chymiferous sac, I have not succeeded in discovering a regular alternation between the contractions of the right and left sides of the system. It may be also, that, the transverse diameter being so much shorter in this genus than in Pleurobrachia and the means of establishing a retrograde current from the periphery very extensive, the circulation takes place through alternate dilatations and contractions of the whole body, causing an injection of the fluid in all directions, rather than by an alternate passage from one side to another; and, for various reasons based upon analogy, I incline to this view. In the Discoid Medusæ we have an absolutely radiating circulation, and a movement simply to and fro from the centre to the periphery and back throughout the whole system. In Pleurobrachia there is an alternation between right and left, with a prominent circulation to and fro. In Bolina there is also a bilateral symmetry, but the radiating circulation seems to be recurring in itself through a complete circle in the lobes and around the mouth, which arrangement would already approximate the Beroid Medusæ of the genus Bolina to the type of Echinoderms, though in a lower condition of the circulatory system.

Whatever may be the value of these suggestions, so much is plain, that the digestive cavity constitutes a capacious sac with a longitudinal mouth, the fissure of which opens in the same plane with the circumscribed area precisely as in Pleurobrachia, in an oblong disk, extending with its longer diameter flat between the anterior and posterior lobes (*Fig.* 91). This disk is entirely surrounded by the large lobes when they are shut, but it forms the lower outline of the body when the lobes are entirely open and fully spread. In this attitude the mouth is shut, but the lobes are wide open, to inclose any food that may come within reach; and whilst dropping fragments of oysters upon them, as they are generally turned mouth upward, in this extreme state of dilatation, I have sometimes seen the lobes close upon such morsels to secure them, and afterward the mouth expand and open within to swallow the food, the tentacles being alternately drawn out and retracted.

The visible outline of the digestive cavity changes most remarkably in these various operations. When the mouth is shut and the digestive cavity is empty, the digestive sac is completely flattened and compressed in the direction of the longer diameter, rising like a tapering funnel toward the central chymiferous cavity; that is to say, the folds of the digestive sac which are stretched between the anterior and the posterior angles of the mouth converge towards the abactinal extremity of the body, and the flattened walls are pressed upon each other. In this position the cœliac chymiferous tubes run in a straight course toward the actinal pole along the middle of the outer surface of the digestive cavity, and reach, near the lateral margin of the mouth, the sac of the tentacles. But after food has been swallowed, the mouth is contracted into a more sphincter-like shape, and the digestive sac itself is so much narrowed immediately above its external opening, that the digestive cavity appears like a loose bag suspended in a mass of transparent jelly, widest about half its height, with prominent angles in advance and backward, and also swollen laterally, but tapering above and below. In such a state the cœliac chymiferous tubes have a more curved, and even sinuous course, upon the sides of the digestive cavity, in accordance with the position of the morsels of food within, whilst the upper end of the digestive sac opens freely into the central chymiferous cavity. Along the abactinal end of the digestive sac there are, as in Pleurobrachia, marked vertical folds, of a brownish color, much darker than the transparent walls of the other parts of the sac; but I have failed to see distinctly the vibratory cilia of its abactinal opening, which play so conspicuously about this region in Pleurobrachia, though there is also in Bolina a constant movement of the minute particles of digested food about the aperture leading from the digestive cavity into the chymiferous cavity.

As mentioned above, the central chymiferous cavity and its funnel are not only shorter, but also narrower, in the genus Bolina, than in Pleurobrachia, and the fibrous appearance of the cell walls of that region is very distinct. The actinal part of this cavity has also a somewhat different form from that of Pleurobrachia, though it exhibits the same general disposition,—its sides bulging simply outward, instead of forming two distinct trunks for the branches to the ambulacral tubes, as in Pleurobrachia. The four main branches, from which the eight ambulacral tubes are derived, arise in pairs, almost directly from the main cavity, and, bending slightly sideways, run almost parallel with one another in opposite directions, that is, forward and backward. The ambulacral tubes themselves present a remarkable arrangement: those of the lateral spheromeres being much further apart from one another than the anterior or the corresponding posterior ones, and diverging sideways, while those of the anterior and posterior spheromeres follow a more direct course forward and backward, owing, no doubt, to the lateral compression of the body. And from the wide space between the two main branches of one side arise the vertical tubes which descend along the digestive cavity toward the base of the tentacles, as well as the tentacular tubes themselves, the cœliac tubes occupying the proximal, and the tentacular tubes the distal side of the lateral interambulacra.

Again, the four main branches of ambulacral tubes, instead of stretching horizontally toward the ambulacra, as in Pleurobrachia, are bent toward the abactinal area, and then divide each into two branches, to provide the eight ambulacra with as many vertical ambulacral tubes. The consequence of this arrangement is, that the impulse of the liquid pressed into the ambulacral tubes is chiefly in one direction, the branches from the main cavity meeting the ambulacra near their upper termination, and not at about half their height, as in Pleurobrachia. So that the chief, and, I may say, almost the only constant current, is from the abactinal side of the body toward the actinal region, along the sides, following the ambulacra and all the sinuosities of their tubes in their lower course through the great lobes, as well as through the lateral auricles; and a comparatively small portion of fluid flows through the comparatively short abactinal end of the ambulacral lobes toward the circumscribed area. The ambulacral tubes therefore are not the direct prolongation of the eight forks of the main branches of this system, any more than in Pleurobrachia, but form an angle with these forks; and there is an abactinal prolongation of the ambulacral tubes, as well as a main actinal branch, above and below the insertion of the fork from the main trunks. I therefore question the accuracy of those illustrations of the ambulacral tubes which represent them as the direct prolongation of the forks arising from the main trunks.[1] The antagonism between the main currents is thus between the upper and the lower side of the body, and by no means between the right and the left side, as in Pleurobrachia. Whether, however, the retrograde current runs exclusively backward through the same tubes in which it has moved onward, or whether the winding course of the narrow tubes in the lobes constitutes a kind of capillary system, through which the liquid may pass from one side of the ambulacral tubes into the other, I am unable to decide. But I cannot help thinking that this long, winding course of the ambulacral tubes upon the inner surface of the large lobes and along the margins of the auricles and of the mouth contributes to a more extensive aeration of the chyme in circulation, than the straighter course in the wider vessels of the whole system in Pleurobrachia. Perhaps the more active alternate contractions in Pleurobrachia compensate, by their quicker movements, for the absence of ramifications of the tubes which are so extensive in Bolina.

The tentacular tubes, which run parallel with and upon the sides of the cœliac tubes, enlarge near the middle of the lateral margins of the mouth into a small, bulb-like dilatation, from which a bunch of tentacles may be projected or retracted. But this bulb is by no means so complicated as the tentacular sac of Pleurobrachia. There is no flat disk at the base of the tentacles, no deep socket into

[1] Comp. MILNE-EDWARDS, Ann. Sc. Nat. 2de sér. vol. 16, Pl. III. and 4e sér. vol. 7, Pl. XIV.; WILL, Horæ tergestinæ, Pl. I.; and GEGENBAUR, Archiv fur Naturg. vol. 22, Pl. VII. Should the ambulacral tubes of the genera described in these papers differ from those of the genera I have examined, in such a way as the figures suggest, this would constitute a remarkable, and to me unexpected, difference between them; but the letter-press gives no details upon this point.

which the tentacles may be withdrawn, but simply two narrow tubes arising close together from the main chymiferous cavity, a little outside of the tubes of the digestive cavity, and following the course of the latter to the tentacular bulb. As, on account of the lateral compression of the body, the tubes of the digestive cavity and those of the tentacular bulb are brought into close proximity, they appear, at first sight, to constitute a single cord on each side; but in reality that cord consists of three tubes running in the same direction, which, being close together, are very easily mistaken one for the other, and whose natural connections are still more difficult to ascertain, as the bulb of the tentacle exactly covers the termination of the tube resting immediately upon the digestive cavity and extending to the margin of the mouth. But whenever, by an oblique movement of the margins of the mouth, or by the dilatation of the digestive sac one way or the other, the cœliac tube is moved out of its vertical course, the relative position of the bulb of the tentacular tube with reference to the cœliac tube is changed, it may be seen how the tube following the walls of the digestive cavity divides into two horizontal branches, extending in opposite directions along the lateral margins of the mouth, forward and backward, at right angles with the tube from which they arise. As these branches meet the actinal prolongations of the lateral ambulacra, a direct communication is established between the peripheric course of the ambulacral tubes and the main chymiferous cavity, and this anastomosis very likely gives passage to so much of the circulating fluid as does not return through the same tubes through which it is propelled from the main trunks of the chymiferous system. As for the two small tubes which extend to the bulb of the tentacles, they arise from the same lateral bulging of the main chymiferous cavity from which the lateral tube of the stomach originates, but they arise more vertically.

The greater simplicity of the tentacular bulb of Bolina, when compared to the large socket and complicated tentacular apparatus of Pleurobrachia, has reference, no doubt, to the shortness of the tentacles, and to the circumstance that they are not protruded to any length beyond the margin of the mouth, but simply extend in a winding course forward and backward along that margin, forming, when contracted, a compact bunch, and appearing, when expanded, like a disorderly brush of irregularly curled threads tied together on one side.

The best attitude in which to study the ramifications of the cœliac tubes on the side of the digestive cavity, or rather along the outer margin of the mouth, and to ascertain their position with reference to the tentacular bulb, which lies farther outward, is when the animal is turned mouth upward with its large lobes fully expanded. The mouth then appears like a narrow rim in the centre of the prominent gelatinous mass, encircled by large lobes, which constitutes a sort of compressed isthmus trending backward and forward on the actinal side of the body, and along the margin of which the horizontal tubes from the stomachal tube are seen to extend as far as the outer margin of the lateral auricles, without entering into direct communication with the tubes of the tentacular bulb. (See Plate VIII. *Fig.* 6 of my paper in the Memoirs of the American Academy.)

Parts of the walls of the cells surrounding the central chymiferous cavity, and the main trunks which arise from it, are readily distinguished as fibres, which may be seen to shorten or elongate, and enlarge or contract their cavity. The funnel enlarges on the abactinal side of the body into two distinct branches, forming two bulbs, as in Pleurobrachia, with oblique openings forward and backward, on the sides of the circumscribed area, and with the black speck in the centre. This black speck is covered by a transparent cap, like that of Pleurobrachia. What I have formerly described as a ring, extending in the form of narrow tubes along the margin of the circumscribed area, is nothing but the optical effect of the thickening of the rising edge which encircles the abactinal area. As to the eight narrow bands converging from the summit of the ambulacral combs and supposed to be tubes emptying into this ring, I have ascertained that they are not hollow, but, like similar bands in Pleurobrachia, the direct prolongation of the locomotive flappers fading away as they converge toward the abactinal pole. Their relative position, when converging toward the abactinal pole, differs considerably in the different pairs, the two anterior and the two posterior ones being very near together, almost in the longitudinal axis of the body, while the two lateral pairs are at least as far apart from each other as they are from the anterior and the posterior pairs. The ambulacral tubes are not continuous under these eight bands, and do not communicate here with the central chymiferous cavity; but they communicate with it on the actinal side of the body through the tube encircling the mouth, which directly anastomoses with the lateral ambulacral tubes and indirectly with the anterior and the posterior ambulacral tubes, through the marginal recurrent tube of the large lobes. The currents arising from the main chymiferous cavity run therefore chiefly through the ambulacral tubes, from the abactinal toward the actinal side of the spherosome, with a small eddy toward the circumscribed area. In the prolongations of the anterior and posterior ambulacral tubes the currents may run to and fro from the tube of one of the spheromeres to that of the other, or directly back to the central cavity, or pass through the recurrent marginal tubes of the lobes into the lateral tubes. In the prolongation of the lateral ambulacral tubes the current may pass into the oral tube through the oral anastomoses, or into the large lobes through their marginal tubes; but the current of the cœliac tubes may also run from the main cavity to the sides of the mouth, and thence through the oral anastomoses into the ambulacral tubes. In the tentacular tubes the current is always to and fro, from the main cavity to the tentacular bulb and back. These tubes do not anastomose with the tentacular tubes.

I have not succeeded in making out a distinct nervous system connected in any way with the central tubercle, though numerous fibres diverging in all directions may be seen in connection with the abactinal part of the funnel. But it has always seemed to me that they were contractile fibres, or rather the fibre-like angles of the motory cells, and not nervous threads, for they change their length, and are by no means so symmetrically arranged as might be expected in the nervous system of radiated animals, the disposition of which is known in some of their types. This point, however, and the periphery of the mouth, are the regions to which to look for it; but, notwithstanding all my efforts, I confess I have failed in the search, and only noticed the walls of motory cells. I have already expressed my opinion respecting the nature of the central black speck of Pleurobrachia. This organ presents precisely the same appearance in Bolina, and the same general relations with the surrounding parts.

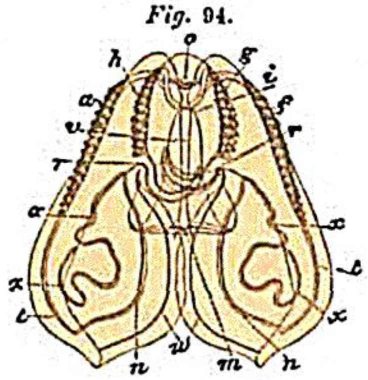
The extraordinary transparency of the gelatinous mass, and the impossibility of preserving the animal after death in a contracted state, forbid the prospect of ever knowing fully the arrangement of the contractile fibres throughout the body, unless we obtain great improvements in the construction of the microscope, enabling us to examine bulky animals alive, and to bury the focus to any depth of the substance of their body without removing the superficial parts. As far as I have been able to trace the structure of the spherosome of Bolina, the general arrangement of its cells is to a great extent similar to that of Pleurobrachia. The radiating system of motory cells is unquestionably the most extensive, though the interambulacral system is the most conspicuous. Parts of the walls of its cells are easily seen as bunches of fibres converging toward the intervals of the successive combs of locomotive flappers, and extending brush-like across the interambulacral spaces, though diverging in each bundle. These fibres seem more powerful, and, at all events, far more distinct, than the vertical fibres, which I have never been able to trace in continuous rows.

Though I first obtained specimens of this species at short intervals through six successive months, from December to June, I never succeeded in discovering the sexual system, not even in the most rudimentary state, until I had an opportunity of watching them uninterruptedly in the latter part of the summer and during the autumn, when I found the ovaries and spermaries following the course of the ambulacral tubes, as first noticed by Will, in Eucharis, and alternating with one another in the eight interambulacra. The circumstance of my failing to trace the reproductive system for so long a time, may show how great difficulties these investigations are attended with, and how much remains to be done before the whole history of these animals is satisfactorily made out. I shall describe their embryonic development hereafter, in connection with that of Pleurobrachia and Idyia.

The extraordinary metamorphoses of certain Echinoderms, which the late J. Müller first observed, ought not to be neglected in connection with the study of the Ctenophoræ; for the remarkable resemblance between the singular transparent frame which protects the growing embryo of some Star-fishes and Sea-urchins and the body of Ctenophoræ Lobatæ cannot be overlooked by an attentive observer, while the fact that the parts of that external frame present numeric combinations which are unusual among Echinoderms, but correspond to those of the Beroid Medusæ, will be an inducement to institute, at some future day, a close comparison between their structure. The ciliated appendages which hang downward in those larval Echinoderms closely resemble the vertical rows of locomotive flappers with their chymiferous tubes, as observed in Beroid Medusæ. And it is interesting to find, that in Echinoderms there is a metamorphosis going on in the embryo, recalling the structure of the class of Acalephs in a manner very similar to the analogy which exists between the embryos of the Acalephs and the Polyps. For whether we compare the Strobila in its earliest conditions, or the young buds of Hydroids from which Medusæ arise, the analogy of these earliest states of development of the Acalephs with Polyps is unmistakable; and I have no doubt that the external frame of the young Echinoderms, which Müller has so beautifully illustrated, will be found to bear the closest resemblance to the structure of the Ctenophoræ, as soon as an actual comparison can be instituted with reference to the homology of their structure. But it is hardly possible to make such comparisons from descriptions and figures, however accurate these may be; and Müller's attention seems not to have been attracted by this remarkable resemblance, otherwise he could not have failed to allude to their typical identity while describing those embryos. So much, however, may already be stated, that the general arrangement of the ciliated lobes of the Pluteus corresponds to the ambulacral rows of the Ctenophoræ, and that the tubes which accompany them compare closely with the chymiferous tubes of the Acalephs; but notwithstanding my constant efforts in studying the embryology of a number of Echinoderms, I have, up to this time, been able to observe the growth of such species only as follow the peculiar mode of development first described by Sars.

BOLINA VITREA *Ag.* is a second species, of which I have seen only a few specimens, at Key West, in Florida. It is easily distinguished from Bolina alata by its more elongated vertical diameter and the narrowness of the locomotive flappers. Its substance is so transparent that it is difficult to follow its movements, even in the clearest glass jars with the purest water; for its ambulacra are scarcely visible as grayish bands upon the sides of the spherosome, and, though iridescent, the play of colors is so faint as scarcely to be noticed. I have not been able to make a thorough study of this species, and therefore limit myself to calling the attention of naturalists to its occurrence on the shores of the coral reef of Florida. *Fig.* 93 gives an outline view of this species; and a comparison with *Fig.* 94, which represents the northern Bolina alata in the same position, may show their specific difference.

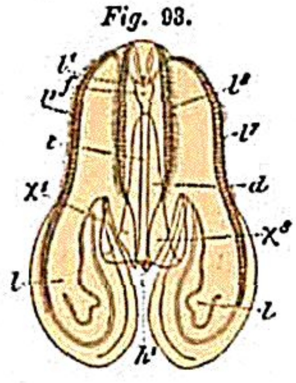
Fig. 94.



BOLINA ALATA, Ag.
(Seen from the broad side.)

a and *f* Long rows of locomotive flappers. — *g* and *h* Short rows of locomotive flappers. — *o* Central black speck (eye-speck). — *i* to *m* Triangular digestive cavity. — *i* to *o* Funnel-like prolongation of the main cavity. — *v* Chymiferous tube of the tentacular apparatus. — *m* Tentacular apparatus on the side of the mouth. — *r r* Ear-like lobes, or auricles, in the prolongation of the short rows of locomotive flappers. — *t t* Prolongation of the vertical chymiferous tubes. — *n n* The same tubes turning upwards. — *x x* Bend of the same tubes. — *z z* Extremity of the same tubes meeting with those of the opposite side. — *w* Recurrent tube anastomozing with those of the auricles.

Fig. 93.

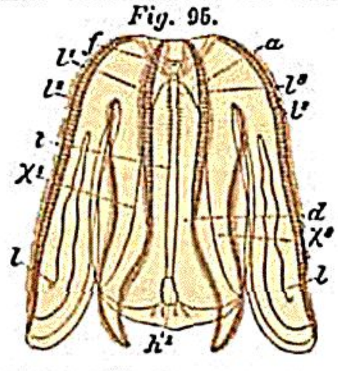


BOLINA VITREA, *Ag.*

l^2 l^7 long ambulacra. — l^1 l^8 short ambulacra. — *f* funnel. — *d* digestive cavity. — *t* tentacular tube. — χ^1 χ^2 auricles. — *l l* anterior and posterior lobes. — h^1 tentacle.

MNEMIOPSIS GARDENI *Ag.* While residing upon Sullivan's Island, near Charleston, South Carolina, I occasionally caught, during the winter, about the breakwater near the Fort, specimens of a species of Acaleph somewhat resembling Bolina, but evidently constituting a distinct genus, which I propose to call MNEMIOPSIS, on account of its still greater resemblance to Mnemia. It is at once distinguished by the deep furrow separating the anterior and posterior lobes from the lateral spheromeres, a character by which the Bolinidæ are readily separated from the Mnemiidæ proper. The generic peculiarity of Mnemiopsis consists in the great development of the auricles, and in the prolongation of the locomotive flappers to the actinal margin of the large lobes, so that the rows of locomotive combs are visible from the actinal side, as well as from the abactinal side, of the body. *Figs.* 95 and 96 represent, in the size of life, the only species I know of this genus. I have called it MNEMIOPSIS GARDENI in memory of Dr. Garden, a distinguished naturalist of Charleston, contemporary of Linnæus and friend and correspondent of the great Swedish naturalist, to whom science is indebted for the knowledge of the large number of the North American animals enumerated in the "Systema Naturæ." This species is very transparent, hyaline, of a milkish white tint, with grayish ambulacra, faintly iridescent. Whether it is identical with the species mentioned by McCrady as *Bolina littoralis* or not, I have at present no means of ascertaining.

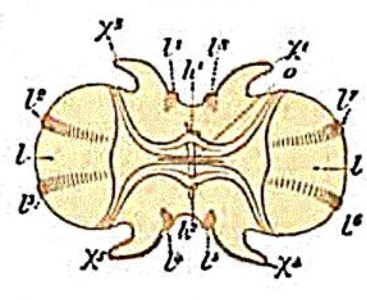
Fig. 95.



MNEMIOPSIS GARDENI, *Ag.*

l^2 l^7 long ambulacra. — l^1 l^8 short ambulacra. — *f* funnel. — *a* folds of the digestive cavity. — *d* digestive cavity. — *t* tentacular tube. — h^1 tentacle. — χ^1 χ^2 auricles. — *l l* anterior and posterior lobes.

Fig. 96.



MNEMIOPSIS GARDENI, *Ag.*

o mouth. — h^1 h^2 tentacles. — l^1 l^8, l^4 l^5 lateral ambulacra. — χ^2 χ^1, χ^3 χ^4 auricles. — *l l* anterior and posterior lobes. — l^2 l^3, l^7 l^6 anterior and posterior ambulacra.

SECTION III.

THE GENUS IDYIA AND OTHER TRUE BEROIDS.

I find it very difficult to trace the natural limits of the genera belonging to the family of the Beroidæ proper. With the exception of Milne-Edwards's illustrations of Beroe Forskåli, all the descriptions and figures of these animals are so imperfect that they afford very indifferent means of comparison; and the circumstance that it is absolutely impossible to preserve specimens of these Acalephs for prolonged examination after their death, necessarily limits all comparative investigations within very narrow bounds. There is another obstacle to a thorough revision of the family, arising from the fact that most species known have only been observed for a short time, and therefore only in one condition of their natural development. Availing myself of the opportunities I have had of studying for the last three years one species of this family in every stage of growth, I am able to state positively that the genus Medea is founded on the peculiarities of the young before they have reached half their size. Several naturalists have already suspected that the genus Medea could not be retained, and that it was based upon the examination of immature specimens. I am able to state with confidence that this is really the case. The genus Medea is characterized by the shortness of its rows of locomotive flappers, which do not extend more than half way from the abactinal side toward the mouth, while in the genus Beroe the ambulacral rows are said to extend all the way to near the margin of the mouth. Now it may be seen (Pl. I.), that, in the smaller specimens of the Idyia of our shore (*Fig.* 6), the rows of locomotive flappers approach less closely to the margin of the mouth in proportion as the specimens are younger; and that, while in the largest (*Figs.* 1 and 2) they extend comparatively much nearer to the edge of the mouth, in the smallest they are so limited as already to answer to the generic character of Medea. I may add, that, in still younger specimens, the difference is even greater. Indeed, in very young specimens, almost too small to be detected by the naked eye, the locomotive flappers are so little developed as to occupy, on the abactinal side of the body, only one third of its height. There can be no doubt, therefore, that the extent of the rows of locomotive flappers does not constitute a generic character among the Beroids proper, without the special qualification that their extent is increasing with age. Eschscholtz mentions the great length of the cilia as another generic character of Medea; but this also is only a peculiarity of the earlier periods of growth, all Ctenophoræ when very young having their rows of locomotive flappers much further apart, in comparison to their size, than the adults, and the cilia themselves much longer, and fewer in number, so that the motions of the young are much more energetic, and quicker, than those of the adults. This will appear very natural, when it is considered that the smaller individuals have the longer oars to move with, and the older and bulkier individuals the shorter locomotive apparatus, according to their size.

But though there are true Beroids in which the locomotive flappers are ever enlarging with age in the direction of the mouth, there are others which, even in their adult condition, have their rows of locomotive flappers limited to as short a range as the young of the former, and, on account of some other peculiarities, may be considered as a distinct genus. I shall take an opportunity hereafter to describe the species of this type which I have observed. The genus Pandora *Esch.* has such limited rows of locomotive flappers; but it differs further in having the abactinal part of the spherosome broader and more rounded, the vertical axis shorter than any of the other true Beroids, and the interambulacra so much developed, as, in their contraction, to overlap the locomotive flappers. As for the genus described by Lesson under the name of Cydalisia, I agree with Gegenbaur that it is founded upon characters which have no generic value, and yet I am not inclined to go as far as he does, in uniting all true Beroids in one single genus; for on comparing the descriptions and figures published by Milne-Edwards of Beroe Forskâli, I find that the species of our coast never assumes that sugar-loaf form which Milne-Edwards represents, but exhibits always rounded outlines on its abactinal side. There must, therefore, be some marked structural difference in the abactinal area of our species and that of the Mediterranean. Accordingly, instead of uniting into one genus all the Beroids which in their adult state have rows of locomotive flappers extending to near the margin of the mouth, I would retain the distinction hitherto made between Beroe proper and Idyia, and refer to the genus Beroe those species which resemble the Beroe Forskâli, and to the genus Idyia those which resemble the Beroe Cucumis of Sars and the species of our coast.

Thus circumscribed, the genus Idyia may be characterized by the inequality of its anterior and posterior spheromeres, compared to the lateral ones; and though this inequality is but slight, it is no doubt sufficient to prevent the abactinal side of the body from being raised into a projecting cone. The structure is this. On their abactinal side the lateral spheromeres are bulging while they converge towards the central eye-speck, whereas the anterior and the posterior spheromeres curve evenly towards the same point. The consequence of this inequality is, that, however much the centre itself may be projected, the anterior and the posterior spheromeres act as bridles upon the lateral ones to prevent the centre from rising into the shape of a cone; while in a state of comparative rest, the abactinal area is depressed in the direction of the circumscribed area, and the lateral spheromeres slightly project upon its sides. I infer that the possibility of protruding uniformly the abactinal end of the body, in Beroe Forskâli, may depend upon an even development of the eight spheromeres on their abactinal side. If this be so, the generic separation of these two animals and their allied species is fully justified. There is another peculiarity which coincides with this difference in form. In Idyia the circumscribed area is very much elongated, and its margin adorned with a row of fringes, diverging forward and backward, and rounded off at its anterior and posterior extremities; while in Beroe proper the fringes encircling the circumscribed area give it a lanceolate form. Had these characters been observed only in two species, they might be considered as specific differences; but all the conical Beroids thus far figured by Mertens and Lesson agree in every respect with that so beautifully illustrated by Milne-Edwards, as closely as those with the dome-shaped outline, figured by Péron, Chamisso, and Sars, resemble that which I have examined. And though the repetition of the same character in several species is not in itself a generic distinction, it is generally a good indication, that such species, having closer affinities, may also present true generic peculiarities not yet observed. As I never had an opportunity of examining a conical species of Beroid, it is impossible for me to give a more direct account of the generic differences of the members of this family. I will therefore only say in conclusion, that, taking Beroe Forskâli as the type of Beroe proper, I would refer to it also Beroe mitræformis of Lesson, the type of his genus Cydalisia, and Mertens's Beroe penicillata; and, taking the species of our coast as the type of the genus Idyia, I would refer to it the oldest species for which it was instituted, and Beroe cucumis of Sars, Beroe macrostomus of Péron, Beroe capensis of Chamisso, and a new species discovered by my son Alexander Agassiz in the Gulf of Georgia.

For our species I propose the name of IDYIA ROSEOLA. This is the species alluded to in my paper on Beroid Medusæ in the Memoirs of the American Academy, which, at the time of its publication, I knew too imperfectly to describe. In the year 1858 it appeared in such quantities upon our coast during the whole summer, that at times it would tinge with its delicate rosy hue extensive patches of the surface of the sea during the warmest hours of the day. It made its first appearance early in July, when all the specimens were of a small size, rarely exceeding an inch or an inch and a half. But it grew rapidly larger and larger, and towards the end of August most of them had reached the size of from three to four inches in vertical height, and about half that size in width, while many had twice these dimensions. At this period they were brightest and deepest in their coloration, the darker colored ovaries, and especially the deep pink colored spermaries, adding to the intensity of their hues. But as the spawning season advanced, and the contents of these organs were emptied, they grew again paler and paler, and, after the eggs and spermatic particles had been entirely discharged, the spherosome itself faded and assumed a livid, pale, grayish color, only a slight tinge of pink remaining. The first September storms broke them all to pieces, and nothing could be found afterwards but floating fragments. This year I have found them again in great abundance, and, as before, they made their first appearance early in July. Several years ago, in 1852, I had also an opportunity of seeing large numbers of them in the harbor of Provincetown on Cape Cod, in the month of August. They had reached about half the size of those seen later, and had probably made their appearance not long before. Afterwards I traced them as far north as the Bay of Fundy, always larger in proportion as the season advanced. But I have never seen them during the winter or in early spring. A careful search, however, made this year by my son, from the beginning of August to the first week of September, led him to the discovery of a large number of young, barely visible to the naked eye. They grew gradually larger; but after the first September gale the young disappeared with the adult, which, as I have already stated, break into fragments in our heavy September storms. The young, of course, must survive; and the question arises, what becomes of them during their temporary disappearance, on the approach of the winter, until the following summer? I can find only one explanation for this phenomenon, suggested by the habits of the adult.

I have already stated, that in the summer months our pretty Idyia appears in great quantities at the surface of the water during the hottest hours of the day. In the morning and evening they are not visible, but as the sun rises above the horizon they may be seen deep below the surface, betrayed by the iridescent colors of their locomotive flappers, and slowly ascending until about ten o'clock, when they are fully in sight near the surface, where they appear in all their beauty. It is thus evident, that these animals may, under different circumstances, voluntarily rise to the surface of the water or dive into the deep; and the nature of the circumstances so influencing them is plainly indicated, not only by the fact that the warmest hours of the day bring them to the surface, but also by the fact, ascertained with equal certainty, that the slightest ripple upon the surface, hardly producing perceptible agitation of the water, is sufficient to cause their instantaneous disappearance, and that they remain out of sight for days in succession when the sky is overcast or the weather chilly. What can be more natural therefore than to assume, that the adult Idyias, having performed their part in life, break up under the influence of the waning summer; while, during the whole winter, the young do what their parents have been doing at intervals during the summer, that is, subside into deep waters, to reappear only with the more genial season, when they complete their growth, reproduce their kind, and die in their turn.

Though our Idyia is slow in its locomotion, its movements are particularly graceful. Its most common attitude is horizontal; that is to say, the main or vertical axis is generally maintained in a horizontal position, or rather slightly inclined, so that the actinal pole, which moves forward, stands higher than the abactinal, which is turned backward. In this respect Idyia coincides with Pleurobrachia, which also moves with the actinal pole forward; but, in its most common attitude, Pleurobrachia stands with its vertical diameter upright. Again: Idyia, while moving horizontally, keeps almost uniformly upon its broad side, and may readily raise its actinal end, with the mouth gaping and ready to seize its prey, as in Pl. I. *Fig.* 8, the flatness of the body facilitating the changes of its attitude. Occasionally it turns, with one or the other side rising; but I have never seen Idyia revolving upon itself around its vertical axis, as Pleurobrachia constantly does, and only now and then does it make somersaults, turning upon its vertical axis in the direction of the broader plane. It should further be remarked, that the older the specimens grow, and the larger they are, the more sluggish become their movements. The young are far more active, and the smallest of them are comparatively quick; but the motion is always a gliding one, long continued in the same direction, with the body stretched to its full length. Only now and then a powerful contraction may be noticed, during which the animal reduces its greatest diameter by at least one third, and, as the spherosome is extremely flexible, it then assumes very varied forms, according to the condition of the digestive cavity. When this is empty, the actinal end may even be turned inside during such contractions (*Figs.* 5 and 5^a); the vertical diameter is then reduced by about one half, and the outline becomes almost circular (*Fig.* 5^a). When the contraction is one-sided, the body curves in various directions. The mouth also may spread or contract, so as to assume the most different outlines: at times gaping widely (*Fig.* 1), at other times contracting in the centre with the opposite ends wide open (*Fig.* 9), or bending sideways (*Fig.* 2^a), or closing up in a straight line (*Fig.* 4), or even shutting by the inversion of its edges (*Fig.* 1 A). When the digestive cavity is gorged with food (*Fig.* 10), the body may be distended in any direction and assume the most irregular shapes.

Our Idyia is very voracious, and feeds chiefly on other Ctenophoræ. Whenever I have kept Bolinas and Pleurobrachias in the same vessel with it, they rapidly disappeared, being generally swallowed entire. In the attempt to seize upon its prey, Idyia readily changes the direction of its motion, but always keeps the mouth forward toward its prey, gaping widely as in *Fig.* 1, and when close upon it turning the edges of the mouth still further outward. A small Pleurobrachia or a small Bolina would frequently pass into its wide digestive sac without any other effort on the part of the Idyia than that of shutting its mouth. But when its prey is larger, perhaps nearly of its own size, our Idyia may be seen distending its mouth to the utmost, and working its prey down into the digestive cavity by repeated contractions, slowly overlapping with the edge of the mouth more and more of the large morsel it is attempting to swallow, until it is finally engulfed. *Fig.* 10 represents an Idyia immediately after it had swallowed a Bolina nearly as large as itself, the outlines of which may be seen in its distended cavity, in a position transverse to the vertical diameter of its own body. If the animal seized upon is too large to be swallowed entire, after forcing into its digestive cavity what is sufficient to fill it, our Idyia will, by powerful contractions of the margins of the mouth, cut off the parts which cannot be swallowed. I have once seen an Idyia, of about the size of that of *Fig.* 7, seize upon a Bolina nearly double its own size, and, after working the abactinal part of the Bolina into its digestive cavity, cut off in that way about two thirds of the actinal side of the Bolina and let it drop. This operation lasted for about an hour; and while portions of the swallowed body showed signs of life in the contraction of the locomotive flappers during three quarters of an hour, the process of digestion was nevertheless going on so fast, that, after an hour and a half, fragments of the indigestible parts, such as the locomotive flappers, began to be discharged through the mouth. In four hours, the whole portion introduced into the digestive cavity had disappeared from it, the more fibrous cell walls and the locomotive flappers being thrown out through the mouth and the more fluid portions passing into the chymiferous system, so that the main chymiferous cavity and all the chymiferous tubes were distended to the utmost, and the fluid contained in them was moving rapidly up and down through the ambulacral tubes into the oral tube and back through the cœliac tubes. Shortly afterward the two cœliac apertures opened successively and discharged some more of the indigestible matter, and the animal seemed as empty as before, with this difference only, that the interambulacral zones, which, when the animal has been fasting, are depressed, and the digestive cavity itself very much flattened, were now distended and presented a rounded outline, as in *Fig.* 3. On another occasion I noticed a large Idyia swallowing a whole Bolina of sufficient size to fill its cavity; and yet, after five hours, no trace of the prey could be observed within it.

From the preceding remarks it may be inferred how difficult it is accurately to describe these animals without prolonged study, under the different circumstances which may modify their appearance. But after collecting many hundreds and keeping them together for weeks at different periods of their growth, in a large tank well supplied with food, I may well say, that the different illustrations published of allied animals observed in other parts of the world, though showing the existence of the genus Idyia in all seas, do not yet furnish us with the means of distinguishing the species inhabiting different zoological provinces with sufficient precision. For not only do the young differ from the adult in the manner already mentioned, the rows of locomotive flappers extending only over a limited part of their surface (*Fig.* 6 and magnified *Fig.* 6[a]), but they are also more rounded, the sides not being so flattened as in the adults. Moreover, the flappers in each row are fewer, and, comparatively to the size of the body, much longer, than in the adults, and the rows themselves much further apart. The chymiferous tubes, which penetrate like a network through the whole thickness of the spherosome, are also much fewer and much less branching in the young than in the adult. Again, before the spawning season approaches, the color over the whole surface is more uniform and paler, as in *Figs.* 7 and 8, the ovaries and spermaries being not yet visible; while in the adult (*Figs.* 1, 2, and 3), they appear as bright rows of branching sacs on the sides of the ambulacral tubes. The arrangement of these organs is so peculiar that it increases the differences resulting already from the inequality of the spheromeres, the ovaries forming broader sacs, of a paler color than the spermaries, which are accompanied by more intensely tinged pigment cells. And then, owing to the fact that alternate interambulacral zones are occupied by ovaries and spermaries, each ambulacrum has ovaries on one and spermaries on the other side of its ambulacral tube, so that, though each ambulacrum is more brightly colored than the intervening space, it is paler on one side than on the other, the pale sides, occupied by the ovaries, being always turned toward each other, as are the bright sides also, which are occupied by the spermaries (*Figs.* 1, 2, and 3). But none of these differences are visible in early life. Again, when well fed the outlines are rounded (*Fig.* 3); but after fasting the interambulacral zones subside and the ambulacral zones become prominent (*Figs.* 1 and 2).

In the plates representing Idyia roseola I have attempted to reproduce the appearance of all the parts of the animal as nearly as possible like life, and have been assisted in this attempt beyond my expectation by the skill of Mr. Sonrel. But so delicate is the substance of this animal, and so slight are the outlines of its different parts when seen through the thickness of the spherosome, that they could only be faintly represented, in order not to exaggerate their natural appearance. Upon careful examination of the figures of Plates I. and II. it may, however, be found, that, faint as they are, the outlines of all the organs are correctly rendered. Yet, to obviate the difficulty that may arise in comparing the descriptions with these plates, I have had wood-cuts made of the most characteristic details of the structure, corresponding to the colored plates and explanatory of them. *Fig.* 10 of Pl. II. is the only one in which the structural details are reproduced with a dark tint which they never had in nature. As already stated when characterizing the family of the Beroids proper, our Idyia has the spherosome of a very uniform thickness, though the spheromeres are not perfectly equal in their size. The anterior and the posterior pairs are somewhat nearer to one another, and their lateral interambulacral expansion is somewhat wider, in consequence of which the outline of the animal appears oval, the sides being more or less flattened.

The cellular structure of the spherosome is easily seen, and, by following the fibre-like outlines of their angles, the arrangement of the cells may be traced without much difficulty. It is much more simple and uniform than in either Pleurobrachia or Bolina, and, owing to the total absence of tentacles and tentacular tubes, no trace of the complicated arrangement of motory cells, which in Pleurobrachia constitute the lateral system, is visible. The radiating system is most prominent, and, in fact, forms the chief bulk of the body. Its general arrangement is that described in Pleurobrachia, with this difference however, that, owing to the much greater elongation of the vertical diameter of the body, the cells of which it is composed form long rows parallel to one another, converging only toward the abactinal pole, but remaining straight on the actinal side. The interambulacral system is the least developed, and, far from forming the doubly convex vertical bands of transverse cells which we have seen in Pleurobrachia, it consists only of a few cells extending between the ambulacra. Hence the marked difference from Pleurobrachia in the outline of the body when seen from either the actinal or abactinal side, the surface of the interambulacra appearing concave (*Fig.* 99, p. 283), unless the body be fully distended, while the ambulacra are raised above the general level of the surface. In Pleurobrachia the reverse is the case, in consequence of the great development of the interambulacral system. But this contrast between the interambulacra and the ambulacra is only striking along the sides, for toward the abactinal pole, and especially beyond the extent of the rows of locomotive flappers, the peripheric system is interwoven with the radiating system, very much as in Pleurobrachia, and the surface of that region of the body is more even. The lateral interambulacra, however, are here somewhat prominent, bulging above the level of the ambulacra about as much as in Pleurobrachia. On the actinal side and beyond the extent of the rows of locomotive flappers, the peripheric system is again interwoven with the radiating system and powerfully developed; and, as the spheromeres do not converge and are not arched on the actinal pole, but extend in a straight course to the edge of the mouth, this part of the body is capable of the most varied and extensive motions. Notwithstanding the prominence of the ambulacra, the ambulacral system of motory cells is not more developed than in Pleurobrachia.

These structural details may explain the characteristic movements of Idyia. The weakness of the interambulacral system forbids a close approximation of the ambulacra, so that the vertical diameter is not reduced by its contractions, but by the contractions of the radiating system, which may go so far as to bend the actinal side of the body inward and reduce the length of the animal in a most remarkable way, as already mentioned. Again, the great strength of the oral system determines the very extensive and powerful contractions of the mouth, and, no doubt, is most active when these animals divide too large a prey.

The slight difference already noticed in the development of the spheromeres is also observable in the extent of the rows of locomotive flappers, and though all terminate at a considerable distance from the abactinal pole, the lateral pairs approach it a little more than the anterior and the posterior pairs; so that the figure circumscribed by their abactinal termination coincides with the outline of the body as seen from that side (*Fig.* 3), and overlaps but little the outlines of the digestive cavity as it appears in the same view. On the actinal side the eight rows terminate at the same height, tapering and narrowing gradually as they approach the mouth, and extending nearer to it in proportion as the animal is older. In the largest, the space on the actinal side not occupied by the locomotive flappers is about one sixth of the vertical diameter, and, in young specimens, about one half. In the smallest specimens that may be seen with the naked eye the locomotive flappers do not occupy one third of the height. As the animal grows larger, the rows of locomotive flappers not only extend farther and farther toward the mouth, but the ambulacral zones become also more prominent and more distinct, not only owing to the growth of the ovaries and spermaries, but also in consequence of the appearance of a larger and larger number of pigment cells in the epidermal layer. At first these are few, far apart, and rounded in form; but gradually they become more numerous, acquire the stellate or branching, and sometimes highly ramified, appearance (Pl. II. *Fig.* 17) characteristic of ordinary pigment cells, varying in color as well as in form. In younger specimens these cells are of a pale yellowish tint, but become more rosy afterward, and those of the adult assume gradually a deeper pink. Now such cells are clustered in larger number upon the spermaries, where they have the deepest color, and, as they extend beyond the locomotive flappers (Pl. II. *Fig.* 17), seem to reach the very margin of the mouth (Pl. I. *Figs.* 1, 2, 4, and 9).

As in all Ctenophoræ, the locomotive flappers consist of combs arranged in rows along the ambulacral tubes; but what is peculiar in the genus Idyia is, that the combs taper very suddenly toward the abactinal pole (Pl. II. *Figs.* 14 and 18), while on the actinal side they narrow very gradually, and disappear so insensibly as to be lost like a thread among the pigment cells (Pl. II. *Fig.* 17). Owing to the steady and slow motion of this animal, it affords the best opportunity to watch the play of the flappers. It may be seen, in *Figs.* 1, 2, and 3 of Pl. I., that the locomotive flappers project beyond the general surface of the spherosome, and also that the waves formed by the flappers along one and the same row when they move successively may be quite distinct (*Fig.* 1), while at other times they seem to move all together (*Fig.* 2). The appearance of the flappers themselves when in different states of expansion and contraction also varies greatly, and hence the different aspects of *Figs.* 1 and 2 in Pl. I. and Pl. II., though they represent identical attitudes, *Fig.* 1 of Pl. I. corresponding to *Fig.* 2 of Pl. II., and *Fig.* 1 of Pl. II. to *Fig.* 2 of Pl. I. Magnified figures (Pl. II. *Figs.* 4, 5, 11, 12, 13, 14, 15, 16, 17, and 18) illustrate these differences still more clearly. In a state of rest, or during slow progression, the combs have their cilia nearly straight (*Fig.* 11), and bent toward the actinal side of the body. When raised into action they curve, gently if the motion is moderate (*Figs.* 13 and 15), and more strongly if the action is more energetic (*Figs.* 12 and 16).

The relations of the locomotive flappers to the ambulacral tubes and to the ovaries and spermaries are more easily traced in our Idyia than in any other Ctenophoræ I have seen. Facing the surface (Pl. I. *Fig.* 3 and Pl. II. *Fig.* 4), nothing can be more evident than that the pouches on the two sides of the ambulacra are not identical, and also that identical pouches are never on the same side of adjoining ambulacral tubes; for pale pouches face another in *Fig.* 4, and both are ovarian sacs, while those on the other side of the ambulacral tube, the spermatic pouches, are almost entirely concealed by the crowded deep pink pigment cells. Now the same parts seen in profile (Pl. II. *Fig.* 13) show the undeveloped sexual pouches to be diverticula of the ambulacral tubes, which retain the same relations to the chymiferous tubes and the locomotive flappers after they have completed their growth and are full either of spermatic particles (*Fig.* 11) or of eggs (*Fig.* 16). This close connection of the sexual organs with the ambulacral tubes and the locomotive flappers is one of the most interesting features of the structure of the Ctenophoræ, because, in my opinion, it shows the close homology which this apparatus presents with the ambulacral system of Echinoderms, and especially with that of the Crinoids with their egg-bearing pinnulæ upon the sides of the ambulacral rows.

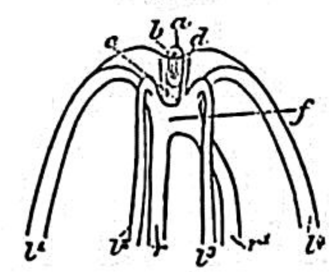
There is hardly any thing among Acalephs equal in beauty to the iridescence of the locomotive flappers of our Idyia, playing with all the colors of the rainbow between the rosy edges of its ambulacral zones. Beyond the rows of locomotive flappers on the abactinal side, eight narrow bands (*Fig.* 3) may also be seen extending to the base of the central eye-speck. These bands consist of slight, immovable projections accompanied by pigment cells. Those extending from the anterior and posterior pairs converge toward the sides of the circumscribed area, which they follow to the eye-speck, while the lateral ones extend straight to the same point. The course of these bands to the very base of the central eye-speck is well shown in our Idyia (Pl. II. *Figs.* 3, 8, 9, and 18), and more easily traced than in Pleurobrachia and Bolina.

The circumscribed area forms a prominent feature of the abactinal pole, being circumscribed by upright branching fringes dotted with many pigment cells (Pl. I. *Fig.* 3; Pl. II. *Figs.* 3, 7, 8, 9, and 18). In *Fig.* 3 of Pl. I. they are represented from above, so that the form of the space they circumscribe is best seen in such a view. The circumscribed area consists, properly speaking, of two oblong, pear-shaped spaces, tapering toward the central eye-speck, and widening forward and backward where their outlines are rounded off. In *Fig.* 3 of Pl. II. their termination near the eye-speck is represented in a magnified view in the same position as in *Fig.* 3 of Pl. I. *Fig.* 9 of Pl. II. represents one of these spaces in an oblique side view, while *Figs.* 8 and 18 represent them in perfect profile from the side, so that their height above the spherosome is plainly visible, the two halves being separated by the eye-speck and its transparent cap. On the side of each of these spaces, about mid-length but somewhat nearer to the eye-speck than to their rounded extremities, may be seen on opposite sides the cœliac openings (Pl. I. *Fig.* 3; Pl. II. *Fig.* 9). *Fig.* 7 represents in an oblique view the bulging of the bulb through which these apertures open. Nowhere among Ctenophoræ are these cœliac openings more easily seen than in Idyia, and nowhere is the circumscribed area more distinct and more prominent. I cannot, therefore, conceive how these animals can have been described by earlier observers as perforated in the centre, unless they were satisfied with the most superficial inspection of very much injured specimens.

Of all Ctenophoræ the Beroids proper have the largest digestive cavity, and in the genus Idyia it seems to have the widest dimensions, judging from the illustrations of the Beroe punctata and Forskåli published by Eschscholtz and Milne-Edwards. That cavity begins with a wide mouth occupying the whole length of the actinal side, where the walls of the spherosome are thinnest, and extends very nearly to the abactinal pole. Its outline, as seen from the broad side of the body, may faintly be traced, especially on the actinal side, through the transparent spherosome, in Pl. I. *Figs.* 2 and 7, and more distinctly in *Fig.* 10, Pl. II., in which the cavity is laid open; while in *Figs.* 1 and 8 of Pl. I. the anterior or posterior ambulacra are so projected upon it as to hide its outlines. In *Figs.* 3 and 4 its outlines are faintly visible from the actinal and the abactinal side. In these specimens the digestive cavity is gorged with chyme, so that the general outline of the body is ovate, and the interambulacra are as turgescent as possible; but the figure is not deformed by the presence of irregular pieces of food as in *Fig.* 10. In such a condition it may be seen how uniform the thickness of the spherosome is in every part of the body. In *Fig.* 10 the outline of the digestive cavity may also be seen distinctly on the actinal side of that specimen, where it is contracted above the mouth, and beyond which it closes over the larger Bolina which fills it. It thus appears, that while the digestive cavity is always wider in the direction of its longitudinal diameter in consequence of its structure, its transverse diameter may greatly vary when it is more or less distended (*Figs.* 3 and 4), but when it is entirely empty and the interambulacra have subsided, its walls are pressed against each other from the side. The whole surface of the digestive cavity is lined with a very peculiar epithelium (Pl. II. *Fig.* 19), resembling somewhat a vibratile epithelium, the cilia, however, being much stouter and blunter than those of ordinary vibratile cells, and resembling somewhat the baculi of the retina. Between them there are rows of branching pigment cells.

The structure of the mouth still requires further investigation. All my efforts to make out the microscopic structure of its edge have thus far been unavailing. From figures drawn in a natural size (Pl. I. *Figs.* 2^a and 4, and Pl. II. *Fig.* 10), it may be seen that the stout vibratile fringes lining the digestive cavity, and the pigment cells intervening between them, are arranged near the edge of the mouth in vertical rows, giving it a striate appearance (Pl. I. *Fig.* 2^a, and Pl. II. *Fig.* 19 magnified). When the mouth gapes, the abrupt termination of these parts gives it a well-defined outline, which may be waving as in Pl. I. *Fig.* 2^a, or double S shaped as in *Fig.* 9, or straight by the apposition of the two sides when the mouth is closed, as in *Fig.* 4. Outside of this well-marked edge and between it and the circular oral tube (*Figs.* 4 and 2^a) is a pale circle, the most movable and most powerfully contractile part of the whole body. *Fig.* 19 of Pl. II. represents that band magnified, in connection with the rows of vibratile cilia and pigment cells of the digestive cavity on the right of the figure, and the superficial stellate pigment cells scattered between the epithelial cells of the outer surface, on the left of the figure. The band without pigment cells, to the left of number 19, corresponds to the pale circle surrounding the mouth. It is evident, from the glimpses I could obtain of this part under the microscope, that cells arranged the edge of the mouth, and that its striated appearance is owing to the fibre-like aspect of the angles of these cells, over which a thick epithelium without pigment cells reaches from the outside to about as near the edge itself as the pigment cells extend on the inner surface. It is with this sharp edge that Idyia cuts its prey. While swimming in pursuit of it with the mouth gaping, the anterior and posterior interambulacra are so contracted as to appear more or less deeply emarginate, and the sides assume the form of two broad lips (*Figs.* 1 and 8).

Fig. 97.

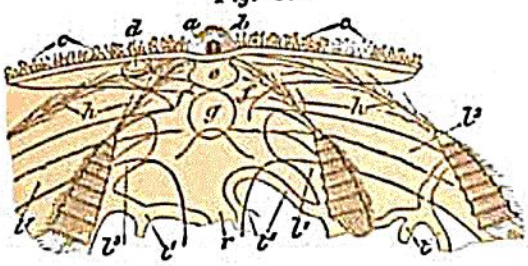


Funnel, or central chymiferous cavity of IDYIA ROSEOLA *Ag.*

a capsule of the eye-speck.—*b* eye-speck.—*c* tubercle of the eye-speck.—*f* funnel.—r^1 cœliac tube upon the distended digestive cavity.—*r* cœliac tube, supposing the digestive cavity empty.—l^1 l^4 lateral chymiferous tubes.—l^2 l^3 anterior chymiferous tubes.—*d* cœliac aperture.

The chymiferous cavity (*Fig.* 97) is very short, though wide; indeed, much shorter than in any other type of this order, and the digestive cavity opens into it through a long fissure, which may gape and contract so as to render it very difficult to trace its outlines, unless the whole chymiferous system be fully distended and the digestive cavity itself empty. Under such conditions and in a side view of the animal (Pl. II. *Fig.* 18 and *Fig.* 98), the origin of the two lateral ambulacral tubes of one side and the anterior and posterior ambulacral tubes of the same side may be distinctly seen arising from an ample common cavity, from which arise also, between the lateral ambulacral tubes, the still broader cœliac tube of that side, the lumen of which, *g*, is projected like a round hole upon the centre of the cavity. Above it, right and left, are the two large forks of the funnel, rising to the surface on the two sides of the central eye-speck, and forming, when projecting outward, the irregular bag represented in *Fig.* 7. This same apparatus may also be seen in *Figs.* 2 and 3 of Pl. I. In *Fig.* 3, the outline of the whole system may distinctly be traced in faint outlines, from the abactinal pole, the eight chymiferous tubes nearly following the outlines of the narrow bands in the prolongation of the rows of locomotive flappers, and the cœliac tubes running between the lateral ambulacra and projecting beyond the outlines of the digestive cavity.

Fig. 98.

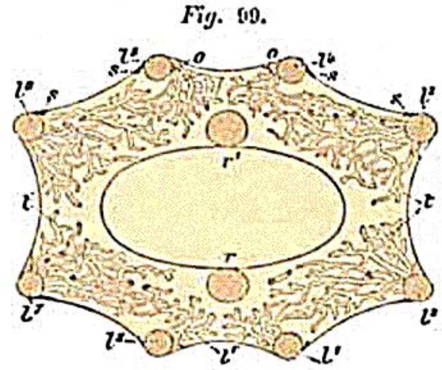


Funnel and chymiferous tubes of
IDYIA ROSEOLA *Ag.*

a capsule of the eye-speck.—*b* eye-speck.—*c c* circumscribed area.—*d* cœliac aperture.—*e* tubercle of the eye-speck.—*f f* forks of the funnel.—*g* opening of the cœliac tube.—*r* cœliac tube itself.—*h h* narrow prolongations of the rows of locomotive flappers.—l^2 l^2 anterior and posterior ambulacral tubes with the flappers of l^2.—l^3 l^1 lateral ambulacral tubes with their flappers.—t^1 t^1 internal ramifications of the ambulacral tubes.

All these tubes follow the course of the ambulacra, from the central chymiferous cavity to the margin of the mouth, where they open into a wide, circular tube encircling the mouth. The tubes are very wide, and their diameter uniform for their whole length. They may best be seen, and their connection with the oral tube is most distinct, in younger specimens (*Fig.* 6ª magnified and *Fig.* 7), in which the rows of locomotive flappers do not cover them. They are also distinctly seen in views from the actinal side (*Figs.* 4, 9, and 2ª), in which the oral tube encircling the mouth is seen to anastomose with all the ambulacral tubes, or rather the ambulacral tubes empty into the oral tube. The cœliac tube may be perceived for its whole length through the thickness of the spherosome between the lateral ambulacra in *Fig.* 2, and to communicate also with the oral tube. This anastomosis is particularly distinct in a view from the actinal side (*Fig.* 4). The course of the fluid contained in this system is somewhat peculiar. The great width of the tubes has reference, no doubt, to the very great size of the digestive cavity; but as they are capable of great extension and contraction, they readily adapt themselves to the quantity of fluid poured into the chymiferous system from the digestive cavity. There is in this family another structural adaptation, which makes it possible for the larger digestive cavity to discharge the nutritive fluid accumulated in it more promptly into the chymiferous system than this takes place in Pleurobrachia. The chymiferous tubes, instead of following a simple course as in the other Ctenophoræ, send off along their whole course innumerable branches, ramifying in the thickness of the spherosome (Pl. II. *Fig.* 10). These ramified tubes,[1] everywhere visible through the transparent spherosome, give it a very peculiar appearance, as if made up of irregular meshes. Nothing of the kind is seen in any other type of Ctenophoræ. The cœliac tubes alone are simple, and do not give off or receive any branches. The origin and ramification of the minor tubes pervading the spherosome present some striking peculiarities. Those of the anterior and lateral interambulacra (*Figs.* 1 and 2), running nearer to the surface and consisting of thinner branches, arise from the ovarian side of the ambulacral tubes, and, in fact, are direct prolongations of the ovisacs; while those occupying the anterior and the posterior pairs of interambulacra have a deeper origin, from the inner side of the ambulacral tubes, and, bending over the spermatic sacs, ramify nearer the inner surface of the spherosome, and are, on the whole, wider than the others (Pl. II. *Fig.* 10). *Fig.* 99, which gives a transverse section across the middle of the body, shows the origin and distribution of these different branches, and makes it evident that none arise, either from the side of the spermatic sacs or from the cœliac tubes.

Fig. 99.



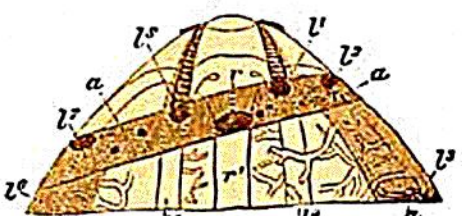
IDYIA ROSEOLA, *Ag.*

Transverse section across the middle of the body.

$r\ r^1$ cœliac tubes.—$l^8\ l^1$, $l^4\ l^5$ lateral tubes.—$l^2\ l^3$, $l^6\ l^7$ anterior and posterior tubes.—$o\ o$ ovaries.—$s\ s$, $s\ s$ spermaries.—$t\ t$ internal ramifications of the anterior and posterior tubes.—t^1 internal ramifications of the lateral tubes.

Fig. 10, Pl. II., representing a vertical section of the whole animal nearly to the abactinal pole where the spherosome is cut transversely, gives the best idea of the ramifications of the chymiferous tubes on the inner surface of the spherosome, and shows how much they differ on that side from those on the external surface (Pl. I. *Fig.* 1). *Fig.* 100 is a reproduction of the abactinal part of *Fig.* 10, Pl. II. Along its margins are seen one of the anterior and one of the posterior ambulacral tubes for their whole length, the corresponding tubes $l^7\ l^2$ (*Fig.* 100) of the opposite side being cut through. In the centre is the large cœliac tube of one side, and its corresponding tube of the opposite side r is cut through. The two lateral ambulacral tubes of one side are also seen for their whole length, and the corresponding tubes of the opposite side, $l^8\ l^1$, are cut through. Between the abactinal end of these branches the short but

Fig. 100.



IDYIA ROSEOLA, *Ag.*

$r\ r^1$ cœliac tubes, r is cut near its origin.—$l^8\ l^1$ lateral ambulacral tubes cut near their origin.—$l^7\ l^2$ anterior and posterior ambulacral tubes, cut near their origin; all the cut ambulacral tubes are on the same side of the body; on the opposite side the following organs are visible from their internal face:—$l^6\ l^3$ anterior and posterior ambulacral tubes.—$l^5\ l^4$ lateral ambulacral tubes.—$a\ a\ a\ a$ represents the section of the spherosome.

[1] Among some Echinoderms there is something quite similar to these ramifications of the ambulacral tubes; for I do not doubt that the tube extending throughout the thickness of the shell of

wide central chymiferous cavity may be seen. On the actinal side, half the oral tube is exposed, and on the margins its sections through the anterior and the posterior interambulacra are visible as black specks.

The course of the fluid in all these tubes is very easily traced. Starting from the central chymiferous cavity, the main currents flow toward the actinal side of the body through the ambulacral tubes and empty into the circular oral tube, but, owing to the frequent contraction and great activity of the actinal region, the progress of the fluid is constantly interrupted; it then flows back and moves to and fro in the ambulacral tubes, filling and distending to the utmost their ramifications in the spherosome, and thus distending it in the manner in which erectile tissues are distended by capillary vessels. But when the obstacle arising from the contraction of the actinal region is overcome, the fluid rushes into the circular tube, from which arise also branches ramifying into the spherosome, and then runs back through the cœliac tubes into the central chymiferous cavity. The total absence of ramifications from the cœliac tubes into the spherosome or upon the walls of the digestive cavity shows, that, in this type at least, the essential function of the cœliac tubes is not to provide the digestive apparatus with nutritive fluid.[1] In very young specimens these ramifications do not exist at all, and the chymiferous tubes are as simple as in Pleurobrachia; but as they increase in size there arise a few lateral branches, at first simple, then dividing (Pl. I. *Fig.* 6ᵃ and 6ᵃ magnified), and then becoming more and more numerous and branching more extensively so long as they continue to grow.

The ovaries and spermaries stand in such close connection with the ambulacral tubes and their ramifications, that they are best considered in this connection. In very young specimens the ambulacral tubes are straight, simple canals; but as they advance in age, shallow pouches grow out of them upon the sides, increasing gradually in size and expanding into irregular sacs, sometimes with a broad base tapering gradually, at other times with a narrow base and expanding into irregular vesicular sacs, usually, but not always, continued into slender ramifications penetrating into the spherosome. In these sacs the ovarian and spermatic cells are developed; but, as already remarked, each ambulacral tube produces eggs in the sacs of one of its sides and spermatic cells in the other: and while pigment cells of a pale color line these sacs, superficial pigment cells of a deep pink color are

the Clypeastroidæ, and forming a regular circular tube along the margin in the Scutellidæ, are homologous to the lateral tubes of the Beroids branching from the ambulacral tubes in the spherosome. In Echinoderms, however, the tubes send off suckers similar to though smaller than the ambulacral tubes.

[1] Milne-Edwards represents the cœliac tubes as ramified in Beroe Forskâli, Ann. Sc. Nat. 2d. sér. vol. 16, Pl. VI. *Fig.* 1ᵃ, *b*. It certainly gives off no branches at all in our Idyia, nor have I seen any such ramifications of the cœliac tubes in the other true Beroids which I have observed.

crowded upon the surface of the spermatic sacs, so that all the ambulacral rows appear one-sided, on account of the prominence imparted to them by the pigment cells crowded over the spermatic sacs. Moreover, the ovarian and the spermatic sacs are developed on opposite sides in adjoining ambulacra, so that proximate sides of different ambulacra have the same kind of sexual organs, while alternate interambulacra have different kinds, the total arrangement being such that ovaries occupy the anterior and the posterior interambulacra, as well as the lateral interambulacra in which trend the cœliac tubes, while the four intervening interambulacra are occupied by spermaries. The sexual sacs begin to appear early in August or in the latter part of July. They are filled with eggs and spermatic cells in the latter part of August; and at that time, in the larger specimens, these may be seen circulating in the ramified tubes arising from the ambulacral tubes, which soon fill so completely with eggs (Pl. II. *Fig.* 6) as to appear like blood discs in a blood-vessel. Owing to the ramifications of the ambulacral tubes and the extension of the ovisac in the shape of similar branches extending into the spherosome, while the spermatic sacs communicate only with the main tubes of the ambulacra, it follows that the contents of the spermaries are emptied into the ambulacral tubes, and through them circulated into the ovarian sacs as soon as the eggs begin to pass into the ramifications of their pouches, and, finally, eggs and spermatic particles are lodged together in the ramifications of the chymiferous system, which penetrate the spherosome, where the eggs remain enclosed until the spherosome itself is broken up and decomposes, when the eggs and the young, in various stages of development, are set free. This constitutes a marked difference from Pleurobrachia and Bolina, in which the eggs are only moved to and fro through the main chymiferous tubes.

The central eye-speck (Pl. II. *Figs.* 3, 8, 9, and 18) has the same structure as in Pleurobrachia and Bolina, and may be so easily observed, that, were there distinct nerves connected with its bulb, I could hardly have failed to see them. That the eight narrow branches converging under the base of its bulb (Pl. II. *Fig.* 3) are not nerves, but a direct prolongation of the rows of locomotive fringes, presenting in their abactinal extension (Pl. II. *Figs.* 8 and 9) the same character as on their actinal prolongation (*Fig.* 17), is easily ascertained; and the circumstance, that while they are plainly visible at the two extremities of the rows of locomotive flappers nothing of the kind can be seen under them, not even when the ambulacra are examined from their inner surface as in *Fig.* 10, shows distinctly that they form a part of the system of locomotive flappers. But why they should reach the base of the eye and terminate there is not so easily understood; unless it is to establish a connection of some kind between sight and locomotion, in the same way as the eye-specks of the Echinoderms are placed in the prolongation of the ambulacra. This connection seems to me an additional evidence that the eye-speck of the Ctenophoræ is a Cyclopean structure, resulting from the central combination of the several eye-specks occupying in other types of the class a peripheric position at the end of the ambulacral zones. The whole structure of Radiates, however, is so remote from that of the other branches of the animal kingdom, that any attempt to homologize their functions beyond the respective limits of the primary types is more likely to lead to errors than to explain their peculiarities.

Having thus described our Idyia, the question now arises, What are its specific characters? for, if the views I have advocated in the first part of this work are at all well founded, it must be obvious that I have embraced in this description many features which are in no way specific. The fundamental structure of our Idyia, as composed of eight spheromeres, is not a specific character, since it is common to all the Ctenophoræ; nor are the equable development of the spheromeres and the ramifications of the ambulacral tubes specific characters, since all the true Beroids agree in this respect; nor is the absence of tentacular tubes and of tentacles a specific character, since no member of this sub-order has them; nor is the great width of the digestive cavity, nor the limited extent of the main chymiferous cavity, specific, since all the Beroids agree in the development of these parts; nor is the structure of the ovaries and spermaries, nor that of the circumscribed area. But, instead of enumerating anew all the structural details mentioned in this section, I may as well at once express my conviction, that no structural peculiarity can ever be considered as a specific character, since the essence of species does not lie in the plan of structure, nor in its mode of execution, nor in its complication, nor in the combinations which determine the form, nor even in the details of the structure. These categories of structure determine respectively the branches, the classes, the orders, the families, and the genera of the animal kingdom; while the species are characterized by their size, the relative proportions of their parts, their ornamentation, their geographical range, their relation to the elements in which they live, their mode of existence, the duration of their life, their association with one another, the period of their reproduction, the changes they undergo during their life, and their association with other beings. Considering, now, our Idyia in this light, I may say that its most striking specific peculiarities are its great size; the prominence of its vertical diameter; its equable and gradual widening from the abactinal pole toward its middle height, and its still more gradual tapering toward the mouth; its light rosy color, intensified with age, and particularly bright about the sexual organs, and deep pink upon the spermaries during the season of spawning, the color growing deeper in consequence of the accumulation of pigment cells. This species lives along the coasts of New England, and northward: it is found near the shores, and, though sometimes appearing in immense numbers, it cannot be said to lead a gregarious life and to form shoals, as they do not move together, like herrings or mackerels. They feed upon other Ctenophoræ, and are very voracious, their digestion being very rapid. They are short-lived, and appear periodically in the early part of the summer, when their dimensions are one sixth of their full size: they are at first pale, but grow deeper and deeper in color as they enlarge, and are brightest toward the end of the summer during the spawning season; after the ovaries and spermaries have been emptied, they grow paler and paler; and, finally, they are broken up into fragments by the autumnal gales. The young, hatched about this time, probably pass the winter, like most shore animals, in deeper water; and they differ from the adults chiefly in having their rows of locomotive flappers much shorter than afterwards. They are usually found associated with Pleurobrachia, Bolina, and Thaumantias near the surface of the water during the hottest hours of the day; but whenever the sea is rippled or the sky overcast, they sink out of sight below the surface.

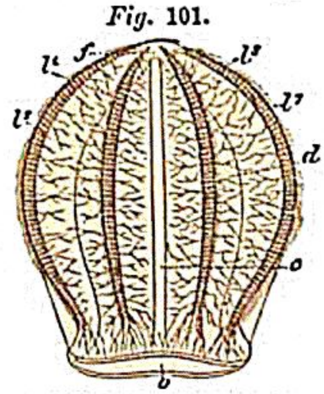
A comparison of Idyia roseola with another species, Idyia cyathina *A. Ag.*, discovered by my son in the Gulf of Georgia, has satisfied me that such are truly the specific characters of our Idyia; for I find that there is not the slightest structural difference between the two, and yet there can be no doubt that they differ specifically. In Idyia cyathina the spherosome widens rapidly from the abactinal pole, and is widest at two thirds of the distance from the mouth, when it again tapers suddenly, and then more gradually, in the same direction; the actinal side of the spherosome being narrower and thinner than the actinal, and therefore much more flexible, and the anterior and posterior interambulacra on that account capable of more extensive contractions, in consequence of which the angles of the mouth may be drawn into very deep curves, and the lips thus formed assume the shape of more distinct lobes than is ever the case with Idyia roseola. It may be said, that though both have the same pattern, Idyia roseola has rather the form of a shuttle, and Idyia cyathina resembles more an Etruscan vase. The habits of Idyia cyathina have not been sufficiently studied to carry farther the comparison of the two species; but, as mentioned above (p. 250, note), so much is already known, that it is also found associated with a Pleurobrachia and a Bolina.

Many years ago I noticed in the harbor of Charleston, South Carolina, and in Florida, two Acalephs belonging to the family of the true Beroids, respecting which my memoranda are very scanty, and quite insufficient to describe them as they should be. And yet I am unwilling to omit them entirely, as they seem to indicate the presence, along our southern coast, of a genus intermediate between Pandora and Idyia, and thus far unknown. Their most striking peculiarity is the shortness of the vertical axis, which barely exceeds the longitudinal diameter. In this respect they resemble the genus Pandora *Esch.*; but they differ from it in having their ambulacra very prominent and the interambulacra concave, while in

Pandora the rows of locomotive flappers lie in a furrow, the margins of which may close over them. They differ further from Pandora in the more extensive development of the rows of flappers, which reach near to the oral tube, and in this respect they resemble more Idyia, with which they agree also in being much compressed laterally. The circumscribed area is bounded by a fringe of deeply lobed processes arranged in two prolonged circles, with the eye-speck between them, in the centre. The eye-speck is not raised on a peduncle. The branching tubes penetrating into the spherosome, which Eschscholtz does not mention in Pandora, are even more distinct than in Idyia; and those arising from the circular oral tube are quite numerous. The main chymiferous cavity, from which arise the chymiferous tubes, is a globular hollow, situated in the abactinal part of the spherosome and communicating with the wide digestive cavity through a narrow fissure. The compression of the body is quite striking, and, upon contrasting a lateral and a front view, these species appear rather flat. For this genus I would propose the name of IDYOPSIS.

IDYOPSIS CLARKII *Ag.* (*Fig.* 101). I inscribe this species to my friend Prof. H J. Clark, to whom I am indebted for a sketch of its outlines, certain that, when he has an opportunity for examining it leisurely, he will give us a most minute account of its structure. From notes made years ago, it appears that the rows of locomotive flappers have on each side a band of yellow and brown stellate dots, and that the edge of the mouth, as well as the fringes around the circumscribed area, were dotted in the same manner. The digestive cavity is occasionally constricted about half way up its height, and may remain so for a long time, while the mouth is broadly opened, and the constriction gliding toward the abactinal end of the digestive cavity may reach the fissure leading into the main chymiferous cavity, and disappear when the latter opens. Seen in profile from its broad side, this species is nearly globular. Found in the harbor of Charleston.

Fig. 101.

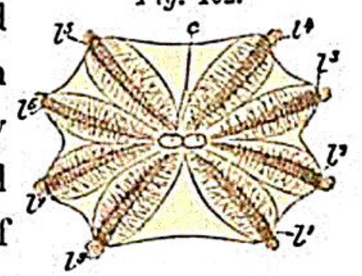


IDYOPSIS CLARKII, *Ag.*

Seen from the broad side.

f funnel.—l^2 l^7 anterior and posterior ambulacra.—l^1 l^3 lateral ambulacra.—*d* digestive cavity.—*o* mouth surrounded by the oral tube, the cœliac tube occupying the centre of the figure.

Fig. 102.



IDYOPSIS CLARKII, *Ag.*

Seen from the abactinal side.

c circumscribed area.—l^1 l^8, l^4 l^5 lateral ambulacra.—l^2 l^3, l^6 l^7 anterior and posterior ambulacra.

IDYOPSIS AFFINIS *Ag.* differs from the preceding in being more flattened in front and behind, and less rounded in its outlines when seen from the broad side, the actinal side being broader. Found along the reef of Florida, at Key West, and about the Tortugas.

SECTION IV.

TABULAR VIEW OF THE CTENOPHORÆ KNOWN AT PRESENT.

In order not to occupy too much room with the following table, I introduce only the names and authority of the species and their principal synonymes, as the references may be found in Eschscholtz or Lesson, and only add such critical remarks as are indispensable to settle questionable statements. I have also carefully revised the indications of all authors respecting the localities in which the species occur.

Order of CTENOPHORÆ *Esch.*: Beroes *Goldf.* 1820.—Vibrantes *Cham.* and *Eysenh.* 1821.—Beroidæ *Esch.* 1825.—Ciliata *Latr.* 1825.—Ctenophoræ *Esch.* 1829.—Iriptères *Rang* 1829.—Ciliobranches and Ciliogrades *DeBlainv.* 1830.

1st Sub-order. LOBATÆ *Esch.* 1825.—Mnemiidæ *Esch.* 1829.

1st Family. EURAMPHÆIDÆ *Ag.* 1860, p. 199.

Euramphæa *Gegenb.* 1856.—Mnemia *Sars* 1857.

E. vexilligera *Gegenb.*—Mnemia elegans *Sars.*—*Mediterranean: Messina* (Gegenbaur and Sars).

Hapalia *Esch.* 1825: Callianira *Cham.* 1821.—Mnemia *Esch.* 1829.—Eucharis *DeBlainv.* 1830.—Polyptera *Less.* 1843.

The validity of this genus is questionable, since it is founded upon an imperfect specimen.

H. heteroptera *Esch.*—Callianira heteroptera *Cham.*—Mnemia Chamissonis *Esch.*—Eucharis heteroptera *DeBlainv.*—Polyptera Chamissonis *Less.*—*Cape of Good Hope, Table Bay* (Chamisso).

2d Family. BOLINIDÆ *Ag.* 1860, p. 200.

Bolina *Mert.* 1833.—Mnemia *Sars* 1835.—Alcinoe *Less.* 1843.—Anais *Less.* 1843.

B. septentrionalis *Mert.*—*Off Matthæi Island, Behring Strait* (Mertens); *Gulf of Georgia* (A. Agassiz).

B. norvegica *Ag.*—Mnemia norvegica *Sars.*—Alcinoe norvegica *Less.*—Bolina hibernica *Patt.*—Alcinoe rotunda *Forb.* and *Goods.*—Beroe bilobata *Dalyell.*—Cydippe quadricostata *Sars*, the young? (Anais quadricostata *Less.*)—*Coast of Bergen, Norway* (Sars); *eastern and southern coast of Ireland* (Patterson).

B. alata *Ag.*—*Coast of New England and northward to the Bay of Fundy* (Agassiz).

B. vitrea *Ag.*—*Reef of Florida* (Agassiz).

Bolinopsis *Ag.* 1860, p. 201.—Bolina *Mert.* 1833.

This genus differs from Bolina in having its anterior and posterior rows of locomotive flappers extending to the bend of the chymiferous tubes, and the abactinal direction of the medial anastomosis of the latter, which trend in the opposite direction in Bolina. The spherosome is papillate, while that of Bolina is smooth. The large lobes are deeply indented.

B. elegans *Ag.*—Bolina elegans *Mert.*—*South Sea* (Mertens).

3d Family. MNEMIIDÆ *Esch.* (restricted).

There are two groups of genera included in this family: Mnemia (Alcinoe), LeSueuria, and Mnemiopsis the body of which is smooth, and Eucharis, Chiaja, and Leucothea with a papillate surface; but, until the structure of these papillæ is better known, the value of this difference in regard to classification must remain doubtful.

Mnemia *Esch.* 1825.

M. Schweiggeri *Esch.*—*Rio Janeiro, Brazil* (Eschscholtz).

M. Kuhlii *Esch.*—*Pacific Ocean, near the Equator, Long.* 180° *of Greenwich.*

Judging from the figure and description of Eschscholtz, this species must be generically distinct from M. Schweiggeri on account of its abactinal appendages.

Alcinoe *Rang* 1829.

A. vermiculata *Rang.*—*Coast of Brazil; abundant in the Bay of Rio Janeiro* (Rang).

A. rosea *Mert.*—*Off the Falkland Islands* (Mertens).

Although this genus is generally adopted, I am strongly inclined to believe that it is founded upon the same species as the genus Mnemia of Eschscholtz. There is nothing in the description of Mnemia Schweiggeri *Esch.* to preclude the possibility of its identity with Alcinoe vermiculata *Rang*, and both were observed in the same locality.

Alcinoe norvegica *Less.* is a true Bolina, B. norvegica.

I am unable to ascertain what Alcinoe Smithii *Forbes* may be. It is said to be found *near Ailsa Craig and on the Irish coast.*

LeSueuria *Milne-Edw.* 1841.

L. vitrea *M.-Edw.*—*Mediterranean: Bay of Nizza* (Milne-Edwards).

Mnemiopsis *Agass.* 1860, p. 269.

M. Gardeni *Ag.* See p. 269.—*Charleston, S. Carolina* (Agassiz).

Eucharis *Esch.* 1825.

E. Tiedemanni *Esch.* — *Northern Pacific. East of Japan* (Eschscholtz).

The genus Eucharis should be limited to the species first described in the Isis in 1825.

Eucharis multicornis *Esch.*, founded upon Beroe multicornis *Q.* and *G.*, is a genuine Chiaja, as far as the mutilated condition of the species allows an identification. At least, there is no other Mediterranean genus to which it may be referred.

Judging from Reynaud's figure, Eucharis novemcostata *Less.*, founded upon Beroe costata *Reyn.*, *from the Indian Ocean, off Ceylon*, is the type of a distinct genus, which may be called EUCHARINA, and the species E. costata.

Chiaja *Less.* 1843.

Ch. papillosa *M.-Edw.* — Alcinoe papillosa *Delle Chiaje.* — Chiaja neapolitana *Less.* — *Bay of Naples* (Delle Chiaje).

Ch. multicornis *M.-Edw.* — Eucharis multicornis *Will.* — Beroe multicornis *Q.* and *G.*? — *Adriatic: Trieste* (Will); *Mediterranean* (Quoy and Gaimard).

Ch. palermitana *M.-Edw.* — *Palermo* (Milne-Edwards).

Considering the extensive geographical range of most Acalephs, it seems hardly probable that there should exist three species of Chiaja in the Mediterranean. I cannot agree with Milne-Edwards, when he considers the genus Chiaja as identical with Leucothea *Mert.* The tentacular apparatus is very different in the two: at least, it is so described and figured by Mertens, Will, and Milne-Edwards as to lead to the impression that there exists a generic difference in the structure of the tentacles of Leucothea and Chiaja.

Leucothea *Mert.* 1833. — Leucothoeæ *Less.* — Leucothoea *Less.*

L. formosa *Mert.* — *Azores* (Mertens).

4th Family. CALYMMIDÆ *Gegenb.*[1] (restricted). — Mnemiidæ *Esch.* — Calymmeæ *Less.*

Calymma *Esch.* 1825.

C. Trevirani *Esch.* — *Pacific Ocean, near the Equator* (Eschscholtz).

C. Mertensii *Less.* — Calymma Trevirani *Mert.* — *Atlantic Ocean, off the coast of Africa, near the Equator* (Mertens). — The separation of this species is founded upon its occurrence in the Atlantic.

[1] Gegenbaur writes it CALYMNIDÆ; but it should be CALYMMIDÆ.

Bucephalon *Less.* 1843.

B. Reynaudi *Less.* — Callianira Bucephalon *Reyn.* — *Off Ceylon* (Reynaud).

Axiotima *Esch.* 1829. — Axia *Esch.* 1825.

A. Gædei *Esch.* — *Pacific Ocean, near the Equator* (Eschscholtz).

Whether this genus belongs to this family, or not, is a matter of doubt. Eschscholtz's description and figure are evidently drawn from an imperfect specimen.

5th Family. Ocyroeæ *Less.* 1843.

Ocyroe *Rang* 1829.

O. crystallina *Rang.* — *Atlantic Ocean, under the Equator, Long.* 32° *W. of Greenwich* (Rang).

O. fusca *Rang.* — *Atlantic Ocean, off Cape Verd Islands* (Rang).

O. maculata *Rang.* — *Among the Antilles* (Rang).

2d Sub-order. TÆNIATÆ *Ag.* 1860. — Cestoideæ *Less.* — Cestidæ *Gegenb.*

1st Family. Cestoideæ *Less.* 1843. — Cestidæ *Gegenb.* 1856.

These family names are objectionable on account of their tautonomy with the Cestoid Worms.

Cestum *LeSueur* 1813. — Sicyosoma *Gegenb.* 1856?

C. Veneris *LeS.* — C. Rissoanum *Less.* — C. breve *Gräffe.* — C. Meyeri *Gräffe.* — Sicyosoma rutilum *Gegenb.* (young?) — *Mediterranean: Nizza* (LeSueur and Risso); *Naples* (Delle Chiaje); *Messina* (Kölliker and Gegenbaur).

C. Najadis *Esch.* — *Pacific Ocean, near the Equator* (Eschscholtz).

C. Amphitrites *Mert.* — *Pacific Ocean, under and near the Equator, Long.* 127° *and* 280° *W. of Greenwich* (Mertens).

C. Mertensii *Ag.* — Mentioned without name by Mertens. — *Atlantic* (Mertens).

Lemniscus *Q.* and *G.* 1822.

L. marginatus *Q.* and *G.* — *Off Timor* (Quoy and Gaimard); *off New Guinea* (Lesson).

The genus Lemniscus was characterized from fragments unquestionably belonging to the family of Cestoideæ; but its generic difference from Cestum remains doubtful. It should be remembered, however, that Eschscholtz has already pointed out differences between C. Najadis and C. Veneris which seem rather generic than specific, and that therefore Lemniscus also may be a distinct genus, even though the facts observed may not, for the present, justify its adoption. But whether the genus Lemniscus be distinct from Cestum or not, the species upon which it is founded certainly differs from the species of Cestum thus far described; so that this family already numbers five species, including that alluded to, but not described, by Mertens.

3d Sub-order. SACCATÆ *Ag.* — Callianiridæ *Esch.*

1st Family. MERTENSIDÆ *Ag.* 1860, p. 196. — Cydippidæ *Esch.*

Mertensia *Less.* 1843 (not *Gegenb.*).

M. Cucullus *Ag.* — Beroe Cucullus *Mod.* — Cydippe Cucullus *Esch.* — Mertensia Scoresbyi *Less.* — Beroe Pileus *Scor.*, nec *Fabr.* nec *Müll.* — Cydippe Cucumis *Less.* (The synonymes of Lesson are all wrong). — Beroe Ovum *Fabr.* (Cydippe Ovum *Esch.*). — *Arctic Ocean* (Martens and Scoresby). — *Baffin's Bay* (Fabricius).

M. compressa *Less.* — Beroe compressa *Mert.* — *Bay of the Holy Cross, mouth of the Anadyr* (Mertens).

Martensia *Agass.* 1860, p. 198.

M. octoptera *Ag.* — Beroe octoptera *Mert.* — Janira octoptera *Less.* — *Coast of Chili: Bay of Conception and of Valparaiso* (Mertens); *Behring Strait, near the Bay of St. Lawrence* (Mertens).[1]

Gegenbauria *Agass.* 1860, p. 198.

G. cordata *Ag.* — Eschscholtzia cordata *Köll.* — Callianira diploptera *Delle Ch.* — *Mediterranean: Bay of Naples* (Delle Chiaje); *Messina* (Kölliker and Gegenbaur).

Owenia *Köll.* 1853. — Mertensia *Gegenb.* 1856.

O. rubra *Köll.* — O. filigera *Köll.* — *Mediterranean: Messina* (Kölliker).

2d Family. CYDIPPIDÆ *Gegenb.* (restricted). — Callianiridæ *Esch.* (partly).

Pleurobrachia *Flem.* 1828. — Cydippe *Esch.* 1829.

Pl. Pileus *Fl.* — Beroe Pileus *Müll.* — Cydippe Pileus *Esch.* — Cydippe Flemingii *Forb.* — Beroe ovatus *Lmk.* — Cydippe ovatus *Less.* — Cydippe pomiformis *Pall.* — Beroe infundibulum *Müll.* — Cydippe infundibulum *Esch.* — Beroe Mülleri *Less.* — Cydippe lagena *Forbes.* — Beroe hexagona *Mod.* — Callianira hexagona *Esch.* — Janira hexagona *Oken.* — Beroe Santonum *Less.* — *Europe: Holland* (Slabber); *German Ocean* (Müller); *Scotland* (Flem-

[1] Although the paper of Mertens gives the coast of Chili and Behring Strait as the home of this species, I suspect, that, in the arrangement of his manuscript, which was printed after his death, the editor may have confounded the memoranda relating to Beroe (Martensia) octoptera with those relating to Beroe (Mertensia) compressa, which is truly an arctic species; for it is hardly credible that the same species should occur in the waters of Behring Strait and on the coast of Chili.

ing); *St. Andrews* (Forbes); *Mouth of the Thames* (Dr. Grant); *Coast of Ireland* (Patterson); *Atlantic coast of France* (Lesson).

Pl. densa *Ag.* — Beroe densa *Forsk.* — Cydippe densa *Esch.* — Beroe Pileus *Risso.* — Beroe albens *Forsk.* — *Mediterranean* (Forskål and Risso).

Pl. rhododactyla *Ag.* — Beroe Pileus *Fabr.* — *New England* (Agassiz); *Greenland* (Fabricius).

Pl. bicolor *Ag.* — Cydippe bicolor *Sars.* — *Norway: Floröen* (Sars).

Pl. Bachei *A. Ag.* — *Washington Territory, West coast of North America* (A. Agassiz).

Pl. Basteri *Ag.* — Beroe Basteri *Less.* — *Coast of Peru, not far from Callao* (Lesson).

Pl. rosea *Ag.* — Beroe roseus *Q.* and *G.* — *Straits of Timor* (Quoy and Gaimard).

Janira *Oken* 1815. — Cydippe *Esch.* 1829.

J. elliptica *Less.* — Cydippe elliptica *Esch.* — *Pacific Ocean, near the Equator* (Eschscholtz).

J. Cucumis *Less.* — Beroe Cucumis *Mert.* — *Between Sitka and Unalaschka, and under the* 36° *N. Lat. and* 211° *W. Long.* (Mertens).

J. elongata *Ag.* — Beroe elongatus *Q.* and *G.* — Janira Quoyii *Less.* — *Atlantic Ocean, off the coast of Africa in* 8° *N. Lat.* (Quoy and Gaimard).

Eschscholtzia *Less.* 1843. — Cydippe *Esch.* 1829.

As the only species left in this genus was described from a drawing, the genus rests upon a very slender basis.

E. dimidiata *Less.* — Cydippe dimidiata *Esch.* — *South Sea, between New Zealand and New South Wales* (Banks and Solander, according to Eschscholtz).

Dryodora *Agass.* 1860, p. 196. — Eschscholtzia *Less.* 1843. — Mertensia *Gegenb.* 1856 (not *Less.*).

This and the next genus are founded upon theoretical grounds, and require confirmation.

D. glandiformis *Ag.* — Beroe glandiformis *Mert.* — Eschscholtzia glandiformis *Less.* — Mertensia glandiformis *Gegenb.* — *Behring Strait: Bay of St Lawrence* (Mertens).

Hormiphora *Agass.* 1860, p. 196. — Cydippe *Gegenb.* 1856.

H. plumosa *Ag.* — Cydippe hormiphora *Gegenb.* — Cydippe plumosa *Sars.* — *Mediterranean: Messina* (Gegenbaur and Sars).

3d Family. CALLIANIRIDÆ *Esch.* 1829, and *Gegenb.* 1856 (restricted).

Callianira *Pér.* 1810[1].

C. triploptera *Lmk.* — Beroe hexagonus *Brug.* — *Indian Ocean, in the vicinity of Madagascar* (Bruguière).

Sophia *Pér.* auctore Lamarck, Anim. s. Vertebr., and Eschscholtz, Isis, 1825.

S. diploptera *Pér.* — Callianira diploptera *Lmk.* — *Indian Ocean, off Australia* (Péron).

4th Sub-order. EURYSTOMÆ *Leuck.* 1856. — Beroidæ Cavæ *Esch.* 1825.

1st Family. BEROIDÆ *Esch.* 1829.

The true characteristics of the species of this family are not yet discovered. Were the synonymy of some authors taken for granted, it would follow that there are species ranging all the world over, which cannot be admitted without the most careful comparison. On the other hand the characters ascribed to the species observed in different localities hardly justify their admission as true species. It is therefore necessary to await further information before considering either the geographical distribution of these Acalephs, or their specific limitation, as satisfactorily traced.

Beroe *Brown* 1756. — Medea *Esch.* 1825. — Cydalisia *Less.* 1843.

B. Forskâlii *Milne-Edw.* — Medusa Beroe *Linn.* — Beroe rufescens *Forsk.* — Beroe ovatus *Lam.* and *Delle Chiaje.* — Beroe elongatus *Riss.* — Idyia Forskâlii *Less.* — Beroe Chiaji *Less.* — *Mediterranean* (Forskâl, Delle Chiaje, Risso, and Milne-Edwards).

B. punctata *Cham.* and *Eys.* — Cydalisia punctata *Less.* — *Atlantic: North of the Azores* (Eschscholtz).

B. Mertensii *Br.* — Idyia Mertensii *Br.* — *Southern Atlantic,* 35° 50′ *S. Lat. and* 22½° *E. Long. of Greenw.* (Mertens).

B. mitræformis *Less.* — Cydalisia mitræformis *Less.* — Idyia penicillata *Mert.* — *Pacific: Coast of Peru,* 6° *S. of the Equator* (Lesson and Mertens).

Idyia *Frem.* 1809. — Medea *Esch.* 1825.

I. ovata *Less.* — Beroe *Brown.* — Medusa Beroe *Linn.* — Beroe ovata *Esch.* — *Tropical Atlantic: Jamaica* (Patrick Brown).

[1] I find it impossible to ascertain positively whether the genera Callianira and Sophia, which Eschscholtz represents as distinct in 1825, and as synonymes in 1829, and for which Lamarck, An. s. Vert., seems to have the priority, really constitute two genera or not.

I. gilva *Less.* — Beroe gilva *Esch.* — *Coast of Brazil* (Eschscholtz).

I. macrostoma *Less.* — Beroe macrostomus *Pér.* and *LeS.* — Idyia Péronii *Less.* — Medea constricta *Esch.* (Beroe constricta *Cham.* and *Eys.*), and Medea rufescens *Esch.*, are probably the young of this species. — *Pacific Ocean* (Péron and LeSueur).

I. Cucumis *Less.* — Beroe Cucumis *Fabr.* — Medea fulgens *Less.* (Beroe fulgens *McCart.*) is probably the young of this species; I would also refer to it Beroe ovata *Dalyell* and Beroe punctata *Dalyell.* — *Baffin's Bay* (Fabricius); *Norway* (Sars); *Coast of Scotland and England, from the Zetland Isles to the Isle of Wight* (Forbes).

I. borealis *Less.* — Beroe fallax *Less.* — Beroe Scoresbyi *Less.* — Medea arctica *Less.* — and Medea dubia *Less.* — all founded upon the figures of Scoresby, are probably one and the same species. — *Seas of Greenland, 75° Lat. N. and from 5° to 8° Long. W. of Greenwich* (Scoresby).

I. roseola *Agass.* — *Coast of New England, and northward to the Bay of Fundy* (Agassiz).

I. cyathina *A. Agass.* — *North-west coast of N. America* (A. Agassiz).

I. capensis *Less.* — Beroe capensis *Cham.* and *Eysenh.* — *South Atlantic, near Cape of Good Hope* (Chamisso).

Idyiopsis *Agass.* 1860, p. 288.

I. Clarkii *Ag.* — *Atlantic coast of North America: S. Carolina* (Agassiz).

I. affinis *Ag.* — *Gulf of Mexico, Tortugas, and Florida* (Agassiz).

Pandora *Esch.* 1829.

P. Flemingii *Esch.* — *Northern Pacific, East of Japan* (Eschscholtz).

2d Family. NEISIDÆ *Less.* 1843.

Neis *Less.* 1826.

N. cordigera *Less.* — *Port Jackson, Australia* (Lesson).

3d Family. RANGIDÆ *Agass.* 1860, p. 191.

Rangia *Ag.* — Idyia *Less.* 1843.

R. dentata *Ag.* — Idyia dentata *Less.* — *Western coast of Africa* (Rang).

SECTION V.

GEOGRAPHICAL DISTRIBUTION OF THE CTENOPHORÆ.

The preceding enumeration may furnish the means of tracing, to some extent, the geographical range of the Ctenophoræ, though it must be apparent, from a survey of the localities where Acalephs of this order have thus far been observed, that much remains to be done before the laws which regulate their distribution can be ascertained. One fact, however, is already plain, that there exist Ctenophoræ in all the oceans, and that they are as common in the arctic as in the temperate and tropical seas; though the range of the different genera and species does not seem to be more extensive or more limited than that of most marine animals. Peculiar genera and species are known to be limited to certain parts of the ocean, while other genera have a wider range and seem everywhere to have special representatives. The Beroids proper are unquestionably the most widely distributed, species of this family having been noticed under all latitudes and in every ocean. Next to them the Saccatæ have the most extensive range; but among these there is already a marked difference between different families, the Mertensidæ having a more northern range than the Cydippidæ proper. Indeed, the genus Mertensia is entirely arctic, while the genera Martensia, Gegenbauria, and Owenia belong to the temperate zone. Pleurobrachia and Janira seem to be cosmopolite, Eschscholtzia and Hormiphora are the representatives of the same family in the temperate zone, while Dryodora is arctic. The Callianiridæ proper belong to the warm regions. The Tæniatæ are entirely foreign to the cold climates, and seem to be more numerous in the tropical regions than even in the temperate parts of the globe where they were first observed. As to the Lobatæ, we find the family of Bolinidæ in the cold and temperate zones, extending to the limits of the tropics; while the Eurampheidæ, the Mnemiidæ, the Calymmidæ, and the Ocyroidæ are almost exclusively tropical, and have only a few representatives in the warmer temperate zones.

If it were certain that the Beroidæ proper are the lowest Ctenophoræ and the Lobatæ the highest, it would follow, that, on the whole, the lower representatives of this order are the most widely distributed, and that the highest are more extensively found in the tropical regions, while those occupying an intermediate position are either cosmopolites, or denizens of the temperate zone, or more tropical. It seems at least to follow from the facts thus far ascertained, that the most elegant and largest representatives of the Lobatæ, such as Chiaja and Leucothea, belong to the warmer temperate and to the tropical zones, and that the most aberrant forms of the whole order, such as Ocyroe and Calymma, are exclusively tropical, Ocyroe being peculiar to the equatorial zone of the Atlantic, while Calymma is found in the Pacific as well as in the Atlantic.

For want of materials, it would be premature, at this time, to attempt tracing with precision the natural boundaries of the Acalephian faunæ. But, in connection with data obtained from other classes, much may already be done towards a better understanding of what zoological provinces truly are. In studying the geographical distribution of animals and plants, naturalists have followed different methods, leading to different results, and bearing in different ways upon the question before us. While investigating the relations under which animals and plants are placed, in different parts of the world, in reference to the physical influences to which they are exposed, we no doubt ascertain much that is of great importance for the limitation of the faunæ; but such studies do not lead, after all, to the knowledge of natural zoological provinces, but only to a fuller insight into the mutual dependence of the organized beings, and the limiting or fostering conditions under which they may live. This study, as I understand it, may end in giving us a more extensive physical history of the organic world, but cannot, by itself, furnish even the foundation for an organic geography, that is to say, for a knowledge of the natural mode of association of animals and plants of the same family or of the same class, which, properly speaking, constitutes natural faunæ or zoological provinces. Nay, this natural mode of association of a variety of animals, belonging either to one and the same class or to different classes and different kingdoms, might be obtained without a deeper knowledge of the physical influences which limit the geographical range of the species considered singly.

Again, much confusion seems to prevail among zoölogists and palæontologists in the use which they make of the word *fauna*. Some designate by it a definite area, within which a variety of animals appears to be naturally associated; and I believe it is in this sense that the term should hereafter be exclusively used. It is self-evident, that if the term *fauna* is applied to such circumscribed areas, and is at the same time used to designate entire zones, over which many distinct zoological provinces may be distributed, as is frequently done when zoölogists speak of the tropical fauna, the temperate fauna, etc., two very different ideas are thus confounded, and no accurate views can be introduced in our science, since in the first case a geographical area is intended, characterized by a peculiar association of various animals, and in the second case a special combination of physical features limiting the range of organized beings. It is far better here to use the expression of *zone*, consecrated in physical geography, and to speak of the tropical zone, the northern and the southern temperate zones, etc.; or, if the two ideas are to be combined, to speak of the faunæ of the tropical zone, in contradistinction to the faunæ of the temperate and arctic zones: for enough is already known of the geographical distribution of animals to make it certain, that the inhabitants of tropical America, of tropical Africa, of tropical Asia, and of tropical Australia, belong to different faunæ, as well as those of the temperate zones of these continents, and of the oceans bathing their shores.

Again, when palæontologists speak of a Silurian fauna, a Devonian fauna, a Carboniferous fauna, a Jurassic fauna, etc., they either prejudge questions which are far from being settled, or, if aware of the difficulties involved in their nomenclature, allow themselves to use this term still more vaguely than zoölogists do. In the first place, neither the Silurian nor the Jurassic era, nor any other of the long eras generally designated by geologists as geological formations, was inhabited from its beginning to its end by the same kinds of animals. Taking, for instance, the Silurian series, within the narrow limits of the State of New York, or the Oolitic series within the limits of the Jura, or the Cretaceous series within the limits of central Europe, we find in each of these series a succession of different species, combined in such a manner as to form a succession of faunæ, the natural geographical boundaries of which may be left out of consideration in view of our present object, but constituting as truly distinct faunæ as the animals living along the Atlantic shores of the southern United States constitute a different fauna from those of the Mediterranean. Here, then, we have, in course of time and within the same boundaries, a succession of faunæ, bearing to one another relations similar to those existing between faunæ of the present period within different boundaries; showing the impropriety of applying the name of faunæ to the organic remains found in these different series, and of using it at the same time for the zoological provinces, as defined by zoölogists, for the animals now living. The matter is not improved by limiting the term faunæ to shorter geological periods. No doubt the fossils found together by Barrande in the lowest fossiliferous beds of Bohemia represent the first fauna of that region. But the "faune première," if it means any thing, must mean the oldest fauna extending over an area, not yet fully defined perhaps, including the first organisms only that lived upon earth in the geographical area now called Bohemia. It cannot at the same time mean any other combination of more or less closely allied species, living at the same period, in other parts of the world; unless it be at the same time shown, that, in these earlier ages of the world's history, there were no faunal differences among animals. Enough, however, is already known of these primeval inhabitants of our globe to leave no doubt, that, though the differences in their geographical range may not everywhere be so striking as they are now, they nevertheless differed in different parts of its surface; so that, to extend the expression of "faune première" to all the inhabitants of the globe belonging to the geological age of the lower Silurian deposits of Bohemia, is to introduce the element of time in the definition of fauna, which is foreign to it.[1] If the expression of "first fauna" could be made to mean all the animals of that epoch, then we should in the same way be justified in speaking of the present fauna as including all the animals now living upon earth; while it is well known that there are numerous faunæ at present ranging over our globe, as there no doubt have been at all times. We may speak of the "first era" or "first period" in the development of animal life upon earth, but certainly not of the "first fauna;" though we may say that the "Bohemian fauna" of the first geological era has been described in a masterly manner by Barrande. In so doing we shall avoid confounding geological periods with geographical areas. In the same way will it be necessary to distinguish between the French, the German, and the English faunæ of the different geological horizons of the Jurassic and of the Cretaceous series. We shall have a German and an English fauna of the Lias period, a Swiss and a French fauna of the Neocomian period, etc., etc., as soon as the natural boundaries of all these faunæ, for all the successive geological epochs, have been satisfactorily traced. And the surest method to advance the solution of this problem is, unquestionably, to distinguish carefully the different elements of the question before us, and not to confound time and space.

These distinctions being admitted, we may now proceed to consider the Acalephian faunæ of the present period, as characterized by the Ctenophoræ. I have already alluded to the relations noticed between the representatives of the different families of this order, and the physical conditions under which they live. It remains to examine their combinations in different zoological provinces.

The arctic regions having been scantily explored, as far as the Acalephs are concerned, it can hardly be expected that much should be known of the faunæ of this zone; and yet it already appears, from the observations of Martens, Scoresby, and Mertens, that the northernmost parts of the globe are inhabited by Acalephs which differ from those of the boreal zone. Mertensia Cucullus and M. depressa are the two most northern Ctenophoræ known; and if these two species prove to be really distinct, it would follow, that the Atlantic side of the Arctic Ocean, on which Idyia borealis is found with Mertensia Cucullus, forms a distinct fauna from that of the Pacific side, where Dryodora glandiformis accompanies Mertensia compressa.

In the boreal zone we may already distinguish three faunæ: 1°, a Scandinavian fauna; 2°, an Acadian fauna; and, 3°, a Columbian fauna. The Scandinavian fauna is characterized by Bolina norvegica, Pleurobrachia bicolor, and Idyia Cucumis; the Aca-

[1] Barrande has already shown that "the range of distribution of the Trilobites, during the period of three successive silurian faunæ, was more limited in the direction from Sweden to Bohemia, than is the case with the living Crustacea." Parallèle entre les dépots siluriens, etc., p. 67.

dian fauna by Bolina alata, Pleurobrachia rhododactyla, and Idyia roseola; and the Columbian fauna by Bolina septentrionalis, Pleurobrachia Bachei, Janira Cucumis, and Idyia cyathina.

The Celtic fauna with its Pleurobrachia Pileus, and the Lusitanic fauna with its rich array of Chiajas, its Euramphæa, its LeSueuria, its Cestum, its Gegenbauria, its Owenia, its Pleurobrachia, its Hormiphora, and its Beroe Forskâli, are barely represented, in the Carolinian fauna, by its Mnemiopsis and Idyopsis. The Charybæan fauna thus far only numbers four species, Bolina vitrea, Ocyroe maculata, Idyia ovata, and Idyopsis affinis; while the Brazilian fauna has two, Mnemia or Alcinoe, and Idyia gilva and the Azorian fauna three, Leucothea formosa, Cestum Mertensii, and Beroe punctata. Off the coast of Africa, further south, the following species have been noticed: Calymma Mertensii, Ocyroe crystallina and fusca, Rangia dentata, and Janira elongata. The South African and the Patagonian faunæ are scarcely known. Off the Cape of Good Hope, Hapalia heteroptera, Beroe Mertensii, and Idyia capensis have been noticed, and Alcinoe rosea off the Falkland Islands.

In the Indian Ocean we may already distinguish the fauna of Madagascar, and in the Pacific that of the low Islands, as distinct from that of Western Australia and of the Sunda Islands. Off Madagascar, Callianira triploptera is mentioned. About Australia, Sophia diploptera, Eschscholtzia dimidiata, and Neis cordata have been found; about Timor and New Guinea, Lemniscus marginatus and Pleurobrachia rosea; off Ceylon, Eucharina costata and Bucephalon Reynaudi. On the coast of Japan, Eucharis Tiedemanni, Janira Cucumis, and Pandora Flemingii seem to indicate a special fauna; on the coast of Chili and Peru, Martensia octoptera, Pleurobrachia Basteri, and Beroe mitræformis point to another; while Bolinopsis elegans, Mnemia Kuhlii, Calymma Trevirani, Axiotima Gædei, Cestum Najadis and C. Amphitrites and Idyia macrostoma have been indicated, without special localities, as found in the Pacific, though it is not to be taken for granted, on that account, that these species have necessarily a wide range of distribution. But how much remains to be done here before the boundaries of most of these faunæ can be defined, may easily be inferred from the fact, that a dozen species only are known from the whole expanse of the Pacific, exclusive of the coasts of Asia and America.

EXPLANATION OF THE PLATES.

In order not to spoil the appearance of any of the most delicate and of the smallest figures drawn upon the following plates, which require a large number of signs to explain their details, I have only added special references to the largest of them, or to those which would not be injured by crowded marks of every kind; but, to supply this deficiency, I have had wood-cuts made corresponding to the figures requiring the most minute explanations, and trust that the others will explain themselves by comparison.

PLATES I. and II.

IDYIA ROSEOLA *Ag.*

[All the figures of these Plates were drawn from nature by A. Sonrel.]

PLATE I. requires but little explanation. It represents Idyia roseola in different stages of growth and in different attitudes, in the size of life, and with its natural colors.

Figs. 1–3 represent adult specimens; figs. 4 to 10 are not full grown; fig. 6 is a young, magnified in fig. 6a.

Fig. 1 is a view from the narrow side of the body, showing the two anterior or posterior ambulacra and two of the lateral ambulacra, one on each side of the figure. The circumscribed area is visible, but foreshortened, as it trends at right angles with the surface represented.

Fig. 1*a* shows how the lips may close up.

Fig. 2 represents the same animal from the broad side of the body, showing the two lateral ambulacra of one side in the centre of the figure, and two of the anterior and posterior pairs, one on each side of the figure. On the abactinal side the lateral interambulacrum rises above the level of the circumscribed area, which trends in the plane of the figure.

Fig. 2a represents the mouth turned sideways, showing the linear arrangement of the epithelium lining the interior of the digestive cavity.

Fig. 3 represents the abactinal side of the body as it appears when fully distended by the filling of the chymiferous system. In the centre appear the circumscribed area and the eye-speck, towards which trend the eight narrow bands extending from the summit of the ambulacral rows of locomotive flappers to the eye-speck. On the sides of the circumscribed area, nearly midway of its two halves, the cœliac apertures may be seen. Nearly concentrically with the abactinal termination of the locomotive flappers, the outline of the digestive or cœliac cavity may faintly be seen through the thickness of the spherosome, as well as the eight ambulacral tubes which trend in the direction of the locomotive flappers and the cœliac tubes which run between the lateral ambulacra, and are seen projected beyond the outlines of the digestive cavity. The deep pink rows on the sides of the locomotive flappers are formed by the accumulation of pigment cells over the spermaries, while the paler rows on the opposite sides of the ambulacra indicate the ovaries.

Fig. 4 is a view from the actinal side with the mouth shut in a straight line. The outlines of the digestive cavity and the chymiferous tubes are visible through the thickness of the spherosome. The cœliac and the oral tubes are particularly distinct.

Fig. 5 represents a half-grown specimen from the broad side, with the actinal end of the body turned inside into the digestive cavity, in consequence of which the general form appears more rounded than under ordinary circumstances, as may be seen upon comparing fig. 5ª, which represents the same animal in the same condition from the actinal side with fig. 4, in which the mouth is visible.

Fig. 6 is a view of a young specimen, as they appear early in July, magnified in fig. 6ª, to show more distinctly that the short rows of locomotive flappers leave the ambulacral tubes uncovered for half the height of the body, and that the ramifications of these tubes are much fewer and much more simple than in older individuals.

Figs. 7 and 8 represent one and the same specimen, about half grown, from the side in fig. 7, and from the anterior or posterior surface in fig. 8. The locomotive flappers extend already much nearer the mouth than in fig. 6, and the ramifications of the ambulacral tubes are more numerous; but the whole body is still much paler than that of adult specimens.

Fig. 9 is a view of the mouth, contracted in the centre and gaping forward and backward.

Fig. 10 represents a specimen gorged with a Bolina nearly as large as itself, distorting its form to so great an extent as barely to resemble another view of the same, given in fig. 7.

PLATE II. represents structural details of Idyia roseola.

Figs. 1 and 2 show the difference there is in the appearance of the abactinal end of the body when seen from its broad or narrow side. Fig. 1 shows the broad or lateral side, with the lateral spheromere and especially the lateral interambulacrum bulging above the anterior and posterior pairs, and concealing partly the circumscribed area, which however shines through, with the eye-speck in the centre. Fig. 2 shows the narrow anterior or posterior side, with the eye-speck and the foreshortened circumscribed area visible in the trough formed by the depression in the abactinal termination of the anterior and posterior spheromeres.

Fig. 3 is a magnified view of the abactinal pole, representing the position of the eye-speck in the centre of the abactinal area, between the anterior and the posterior halves of the circumscribed area, and with the central termination of the eight narrow bands extending from the summit of the locomotive flappers to the eye-speck. The gray bands forming a zigzag around the eye are the outlines of the funnel.

Fig. 4 represents a magnified band across one ambulacrum and part of another. Right and left of the row of locomotive flappers are the ovaries and the spermaries; the first covered with deep pink-colored pigment cells, and the latter only lined with paler pigment. Another row of ovaries belonging to the adjoining ambulacrum is seen in the same interambulacrum, and the intervening part of the spherosome is traversed by numerous branches of the ambulacral tube, arising partly from the ovarian pouches and partly from the tube itself. Along the spermaries there are no ramifications of the chymiferous tubes.

Fig. 5. The abactinal end of the ambulacrum of a younger specimen, in which the ovaries and spermaries are not yet developed, more highly magnified, in order to show the trend of the cells of the radiating system.

Fig. 6. Ramifications of the chymiferous tubes of an adult specimen more highly magnified, to show to what extent the eggs may be crowded in these tubes, after they have left the ovaries.

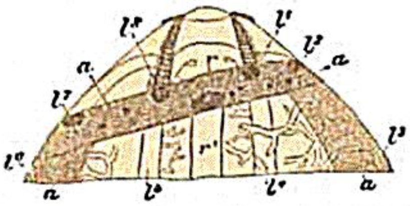
Fig. 7 gives an oblique view of the cœliac bulb, rising upon the side of the circumscribed area. The lower part of the figure represents a part of the surface of the area itself, with its marginal fringes, to show that the cœliac bulb is outside the area, as is again shown in fig. 9, where the cœliac aperture is represented gaping, in the shape of a circular hole.

Fig. 8. Profile view of the eye-speck with its transparent cap, magnified and seen from the broad side of the body, so that only four of the narrow bands are visible below it, and part of the circumscribed area in profile. This figure corresponds exactly to fig. 3, which represents the same parts, and in the same size, from above.

Fig. 9. Circumscribed area on one side of the eye; seen obliquely, in order to show at the same time its entire outline, the surface encircled by its fringes, the cœliac aperture on its side, and the narrow band of one of the anterior ambulacra following its outline.

Fig. 10. Vertical section of the whole body, in the direction of the longest or axial diameter, with the exception of the abactinal side, through which passes a transverse section reaching the digestive cavity. The adjoining wood-cut (fig. A), which represents only the abactinal part of fig. 10, Pl. II., may best explain the parts so brought into view. The actinal part of fig. 10 shows the prolongation of the parts cut through in fig. A, one half of the mouth and one half of the oral tube being cut through in the anterior and in the posterior interambulacra, and the lumen of the oral tube appearing in the thickness of the spherosome. The epithelial lining of the digestive cavity appears as vertical striæ above the margin of the mouth.

Fig. A.



r r¹ cœliac tubes, *r* is cut near its origin.—l^3 l^4 lateral ambulacral tubes, cut near their origin.—l^1 l^2 anterior and posterior ambulacral tubes, cut near their origin; all the cut ambulacral tubes are on the same side of the body; on the opposite side the following organs are visible from their internal face:—l^5 l^6 anterior and posterior ambulacral tubes.—l^7 l^8 lateral ambulacral tubes.—*a a a a* represents the section of the spherosome.

Fig. 11. Profile view of an ambulacral tube, with three rows of extended locomotive flappers and a band of pigment cells upon the spermaries projecting as pouches from that side of the tube.

Fig. 12. Oblique view of seven rows of locomotive flappers, greatly curved.

Fig. 13. Magnified view of an ambulacral tube, with four rows of slightly arched locomotive flappers, and the incipient pouches of the spermaries partly covered by pigment cells.

Fig. 14. Abactinal termination of an ambulacrum, to show how rapidly the rows of locomotive flappers taper on that side, in comparison with their actinal termination, as represented in fig. 17.

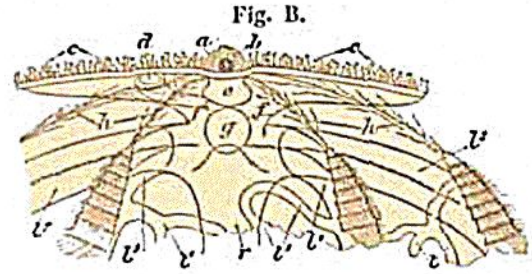
Fig. 15. Profile view of an ambulacral tube, with five rows of slightly arched locomotive flappers. The adjoining interambulacrum is so raised that the row of pigment cells covering the spermaries is seen in profile, while in fig. 13 it is depressed and the whole diameter of the tube is visible.

Fig. 16. Profile view of the ambulacral tube of an adult specimen, slightly magnified, with the adjoining interambulacrum depressed so that the ovarian pouches are fully seen. As these organs and the spermaries are on opposite sides of the ambulacral tubes, the locomotive flappers appear curved in a different direction in fig. 16 and in fig. 13, as they are seen in opposite directions.

Fig. 17. Actinal prolongation of the row of locomotive flappers, tapering to a mere thread and surrounded by branching pigment cells. Here the underlying ambulacral tube, from which arise two small branches on the same side, is much broader than the row of flappers. It is interesting to notice, that even in the prolongation of the tube beyond the ovaries and the spermaries, the pigment cells are much more crowded on the spermatic side of the tube than on the opposite side, and that the branches extending into the spherosome arise only on its ovarian side.

Fig. 18. This figure is reproduced in the adjoining woodcut, fig. B. It represents the abactinal pole of our Idyia in profile and sufficiently magnified to show the relations of the central chymiferous cavity to the ambulacral and cœliac chymiferous tubes, to the forks of the funnel, and to the cœliac aperture.

Fig. B.



a capsule of the eye-speck.—*b* eye-speck.—*c c* circumscribed area.—*d* cœliac aperture.—*e* tubercle of the eye-speck.—*f f* forks of the funnel.—*g* opening of the cœliac tube.—*r* cœliac tube itself.—*h h* narrow prolongations of the rows of locomotive flappers.—l^1 l^2 anterior and posterior ambulacral tubes with the flappers of l^2.—l^3 l^4 lateral ambulacral tubes with their flappers.—t t^1 internal ramifications of the ambulacral tubes.

Fig. 19 is fully explained on page 281 of the text.

PLATE IIa.

Pleurobrachia rhododactyla.

[Figs. 1 to 10, and 21, 23, 24, and 20, drawn from nature by H. J. Clark, the others by A. Sonrel.]

A, B, C, D, E, F, G, H, the eight broad interambulacra trending from the actinal to the abactinal poles: in figs. 20, 21, 22, and 23, they are placed correspondingly, A and E in the plane of the digestive cavity, and C and G in the tentacular plane. These letters also mark the position of the eight interambulacral bands of the peripheric cellulo-motor system, which are shown in a transverse section at the equatorial region.

a, the mouth. It assumes the most diversified outlines when shut, or expanded in various ways.

a¹, the corners of the mouth, or the edge of the digestive cavity, seen in the distance.

b, the actinal part of the digestive cavity.

c, the abactinal part of the digestive cavity upon the walls of which exist the brown hepatic cells, through which the substances which have been digested are emptied into the main chymiferous cavity *d*. There is, at its bottom, an opening *c¹*.

d, central chymiferous cavity. This cavity with its vertical prolongation *f* corresponds truly to the main cavity of Polypi, with this difference, that in Polypi there are partitions dividing it off around the periphery, while in Medusæ the mass of cells forming the body occupies, to a great extent, the inner space of the animal, and leaves only tubes for the peripheric circulation of the fluid contained in it. The vertical prolongation *f* of this main cavity extends in the direction of the circumscribed area, and branches into two forks f^1, f^2, at its termination. The other tubes arising from it are the two main chymiferous horizontal tubes *e*, *e*, with their branches *q*, q^1, and their eight ambulacral tubes i^1 to i^8, which open into the vertical tubes l^1 to l^8. The tubes *r*, r^1, which follow the walls of the digestive cavity, arise also from it near the main horizontal trunks; and from these latter arise the tubes of the tentacular apparatus *a*, *a*.

e, *e*, the main horizontal trunks of the chymiferous tubes, from which arise the eight radiating branches opening into the ambulacral tubes.

f, the vertical or axial funnel-like prolongation of the main cavity of the body. f^1, f^2 the two forks of that funnel. It should be remarked, that the direction of that fork is in the plane of the longest diameter of the circumscribed area, which is also the direction of the longitudinal diameter of the mouth.

g, the roots of the tentacle; g^1 the edge of the ridge of the tentacular base; g^2 the side of the ridge.

h, h^1, h^2.—*h* designates the whole tentacular apparatus with all its complicated parts, h^1 being the tentacular apparatus of one side, and h^2 the tentacular apparatus of the other side. These numbers are appropriated to the same apparatus in every figure, whatever may be the position in which the animal is observed. It will be noticed, that these tentacles are placed at right angles with the plane of the mouth and of the circumscribed area.

i, the eight horizontal tubes of the chymiferous apparatus which reach the vertical tubes, following the vertical rows of locomotive flappers. In all the figures the horizontal tubes are numbered in the same way, beginning with No. 1 and ending with No. 8. No. 1 is assigned to that tube which extends to the vertical row in sight on the left hand when the mouth is turned upward and the tentacular apparatus appears symmetrically on the right and on the left; so that i^1, i^2, i^3, i^4 are the four horizontal tubes of one half of the body, and i^5, i^6, i^7, i^8 are the four horizontal tubes of the opposite half. And if the view I have taken of the diameters of these animals is correct, that the longitudinal diameter of the mouth divides the body into symmetrical halves, one to the right and the other to the left, the tubes i^1 to i^4 are the tubes of the anterior half, and the tubes i^5 to i^8 are the tubes of the posterior half, and the tubes i^3, i^1, i^8, i^7 are the tubes of the left side, and the tubes i^2, i^4, i^5, i^6 are those of the right side, or *vice versâ*, as we can only establish these general relations between the different diameters without determining strictly which is the anterior and which is the posterior edge of the mouth. It is probable, however, that no distinction is intended in the structure of these animals, as they are capable of assuming inverse positions, mouth upward and mouth downward, in which case the edges of the mouth appear in an inverse position.

j, the tentacular socket or cavity in which the tentacular apparatus is suspended, and to the inner wall of which it is attached. This cavity opens at j', and through this opening the tentacle may be extended; but it is also capable of such contraction as to be entirely withdrawn within the cavity *j*.

j', opening of the tentacular cavity, through which the tentacle is protruded.

k, the main stem of the tentacle from which the fringes arise.

k', fringes of the tentacles which arise uniformly upon the same side, the outside, of the tentacle, so that they are stretched in opposite directions from the two sides. But this direction is constantly modified in the various attitudes and the various degrees of elongation of the tentacles, as these are capable of being twisted upon themselves; so that the fringes may appear as forming a spiral upon the main stem, or may be stretched in all possible directions, in their more or less extensive elongations. However, at the base they arise strictly in opposite directions.

l, *l*, the vertical rows of locomotive flappers, of which there are eight of uniform length in Pleurobrachia. These vertical rows are numbered in the same manner as the horizontal tubes which open into the vertical chymiferous tubes accompanying the flappers, and these numbers correspond in the different figures, in the same manner as in the tubes; l^1 to l^4 being the rows of one extremity, and l^5 to l^8 those of the other extremity, and l^3, l^1, l^8, l^7 being the rows of one side, and l^2, l^4, l^5, l^6 the rows of the other side.

m, the radial cellulo-motor system around the corners of the mouth.

m^1, the oral motor system.

m^2, the radial system in the tentacular plane.

m^3, the lateral system where it passes from the actinal end of the tentacular sockets to the periphery of the body.

n, the interambulacral motor bands in the plane of the digestive cavity.

n^1, the same as *n*, but in the tentacular plane.

n^3, the abactinal end of the interambulacral motor bands.

n^4, the inner face of n.

n^5, the actinal end of the interambulacral motor bands.

n^6, the tentacular motor system.

p to p^3, the lateral cellulo-motor system; p where the wings from two opposite sides meet; p^1 those cells which pass from the tentacular sockets to l^1, l^2, l^3, l^4, and C and G; p^2 the profile of the inner face of the wings; p^3 the superficial termination of this system, along the borders of m^1. This system is shown only on one half of the figure, in order to avoid confusion.

q, q^1, the four main trunks from which the eight radiating chymiferous tubes arise. It should be noticed, that these tubes are not strictly in the same horizontal plane, since their respective position varies more or less in the different contractions of the body, and those on one side are successively higher than those of the opposite side in the alternate contractions of the opposite halves of the body, which regulate the general circulation of the nutritive fluid.

r, r^1, the cœline tubes following the digestive cavity. They arise from the main horizontal tube, and extend to the margin of the mouth, following the middle of the flat surface of the digestive cavity.

r^2, entrance to r, r^1.

s, the eight epidermic narrow bands of fixed ciliate bodies which pass from the abactinal ends of the rows of locomotive flappers to the base of the cap over the pedunculated globular eye δ.

t, t^1, the radial cellulo-motor system around the axial funnel.

u, rows of locomotive flappers.

v, vertical chymiferous tubes, which accompany, on the inner surface, the rows of locomotive combs.

v^1, the same as v in a contracted state.

w, basal line of the locomotive flappers.

w^1, the sub-ambulacral motor cells, probably continuous with those which constitute the flappers.

x, ganglions? These swellings are more or less evanescent, and appear rather to be small bodies caught in the symmetrically arranged folds of the chymiferous tubes.

x^1 x^2, cells of the interambulacral system on the borders of the sub-ambulacral system x^3.

y, ganglion-like bodies, arising probably from the accumulation of granules in the contracted state of the vertical chymiferous tubes when the circulation has ceased.

a, chymiferous tubes of the tentacular apparatus.

a', the opening through which the vertical chymiferous tubes of the tentacle open into the main horizontal chymiferous tubes between their main forks.

a'' a''', the same as a, one on each side of the tentacular base.

β, elongated disk from which the tentacles arise.

β', margin or outer wall of β.

β'', outer wall in profile at the margin of γ.

β''', outer wall at the thickest part of the disk.

γ, the longitudinal furrow of the disk (in fig. 15), or the keel-like prolongation of the inner layer of the disk between the tentacular tubes, to which it is a wall.

γ', the inner layer of the tentacular base.

γ'', the apex of the disk.

δ, eye-speck in the centre of the circumscribed area.

δ', globular cavity containing the eye-speck δ.

ϵ, the shallow, oblong furrow of the circumscribed area lined with vibratile cilia.

ϵ^1, raised line following the inner outline of ϵ, probably the analogue of that row of fringes so conspicuous around the circumscribed area in some other genera of Beroid Medusæ, and particularly distinct in the genus Idyia.

ϵ^2, another line, parallel to the former and within it, the special nature of which I have failed to ascertain.

ζ, the openings, cœline apertures, of the two bulbs of the vertical funnel, through which the fæcal matters are from time to time discharged.

θ, the tubercle upon which the eye-speck δ rests.

ι, κ, concentric swellings connected with the ganglion of the eye-speck, stretching in the direction of the longitudinal diameter of the circumscribed area.

λ, four ganglionic swellings within the inner of the swollen margins near the ganglion of the eye-speck, the nature of which I have also failed to determine.

Figs. 1–12. Lasso-cells from the fringes of the tentacles. Fig. 1 is magnified 500 diameters, the others 200 diameters, by means of Spencer's one fourth inch objective and Tolles's solid ocular, number E. In all these figures a is the wall of the cell, b the lasso, c the base or point of attachment of b, d the free end of b, e the mouth of the cell, f the granular covering of a.

Fig. 1. A closed lasso-cell as seen with 500 diameters.

Fig. 2. The same as fig. 1, magnified as above, with the granular coating in profile.

Fig. 3. An open cell, partially contracted, and the lasso out.

Fig. 4. Still more contracted than fig. 3.

Fig. 5. The wall almost entirely decomposed.

Fig. 6. The lasso forcing its way through the closed mouth.

Fig. 7. Foreshortened view of fig. 6, the granular coating in profile.

Fig. 8. Profile view of a cell, like fig. 3.

Fig. 9. The lasso partially thrust out, and the rest of the thread distant from the wall, showing that no cell contraction forces it out, but that it is protruded by its own act. The granular coating covers the whole cell.

Fig. 10. Similar to fig. 5, in profile.

Fig. 11. Profile view; the thread extruded, but not uncoiled.

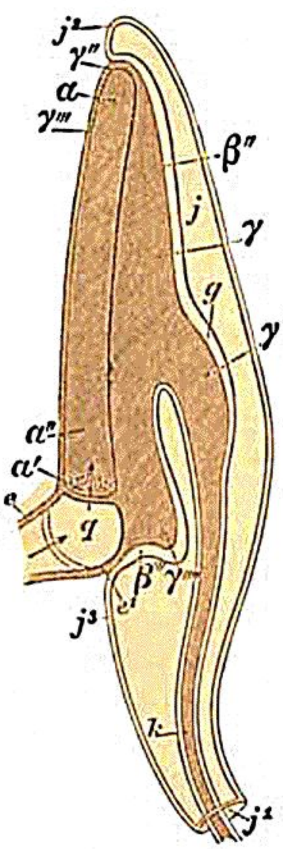
Fig. 12. Showing the same as fig. 9, but more of the thread is out.

Fig. 13. The tip of one of the tentacular fringes. *a* the lasso-cells; *b* the same as *a*, in profile; *c* outer wall; *d* inner wall; *e* transparent axis. 350 diameters.

Fig. 14. Portions of the elongate shallow furrows of the circumscribed area covered by vibratile cilia; the bulb and cap of the eye-speck, the two bulbs of the axial funnel, and the eight epidermic bands of ciliate bodies prolonged from the rows of natatory flappers. 25 diameters.

Fig. 15. The tentacular apparatus as seen from the periphery, to show the mode of the attachment of the tentacle to the disk, and the relation of the latter to the double chymiferous tubes; taken from a half-grown individual. 80 diameters. The better to understand the relations of these parts, a profile view (Fig. C)

Fig. C.



a a'' chymiferous tube.
a' entrance to a.
e wall of the main horizontal chymiferous trunk.
e' wall of the opposite side of e.
g The base of the tentacle.
j tentacular socket.
j^1 aperture of j.
j^2 apex of j.
j^3 proximal side of j.
κ the tentacle.
q point of junction of e and a'.
β'' outer wall of the disk.
β''' same as β''.
γ the inner layer of the disk.
γ' inner layer of the disk at the base of the tentacle.
γ'' the thin proximal wall of a.
γ''' the same as γ''.
γ'''' the thickest part of the same layer.

A full account of the structure of this apparatus may be found on page 235.

of the same apparatus is here introduced, with the same lettering as fig. 15 of Pl. II[a].

Fig. 16. A few lasso-cells from fig. 17. 500 diameters.

Fig. 17. One of the tentacular fringes, showing the lasso-cells to be arranged side by side in an uninterrupted layer *a b*; here and there the threads are out. 350 diameters.

Fig. 18. Transversely sectional view of a contracted tentacular fringe. *b* the layer of lasso-cells; *c* c^1 the outer wall; *d* d^1 the inner wall; *e* the transparent axis. 350 diam.

Fig. 19. The eye and its cap; the bulb underlying the eye; the eight rows of immovable cilia; and the oblong shallow furrow, more highly magnified than in fig. 14. 50 diameters.

Figs. 20, 21, 22, and 23 represent the same animal in four different views, so that, after a careful study, its form might be carved from them.

Fig. 20. A full-grown individual, seen from the abactinal end, to show the organs in their relative position; the eye and the shallow oblong furrow of the circumscribed area are nearest the observer; the tentacular apparatus comes next, and the two great main chymiferous trunks are about the middle of the body. 4 diameters.

Fig. 21. Same as fig. 20; seen from the actinal end, to show principally the relation of the cellulo-motor systems to the organs; the mouth is nearest the eye, then come the tentacular sockets, and lastly the two great chymiferous trunks.

Fig. 22. Profile view, in which one of the tentacles is next the observer, the digestive cavity (*b*) presents its broad side to the eye, and the bulbs (f^1 f^2) of the axial funnel stand right and left.

Fig. 23. View at right angles to fig. 22. The tentacles stand right and left, as do also the two chymiferous tubes (*r* r^1) which embrace the digestive cavity; the latter (*b*) presenting its edge to the eye.

Fig. 24. The enormous cells of the cellulo-motor systems. These are from the radial system. *a* the wall; *b* same as *a*, but contracted and wrinkled; *c* the wavy face of *b*; *d* transparent cavity of the cell; *e* the slender points of the cells. 500 diameters.

Fig. 25. An individual, natural size, swimming with its tentacles trailing behind, and the fringes curved, waved, bent at various sharp angles, and stretched to the utmost or closely retracted. For other views, see my paper in Mem. Amer. Acad. Vol. IV. Pl. I.

Fig. 26. One of the natatory paddles and the subjacent cells of the cellulo-motor systems, to show the relation of the cells of the paddles to those of the motor system. 50 diameters.

PLATES III., IV., V., and V^a.

CYANEA ARCTICA, *Pér.* and *LeS.*

[All the figures of these plates were drawn from nature by A. Sonrel.]

PLATE III. represents Cyanea arctica in one of its natural attitudes, quietly floating near the surface of the water with all its appendages hanging loosely down, most of the tentacles being fully extended, and a few only contracted. The attitude chosen makes it possible to appreciate the position of the different parts, in their natural relations, as seen in profile. One of the pillars of the digestive cavity being in the centre of the figure, two of the ovarian pouches are visible to the right and left of it, behind the curtain formed by the four bunches of tentacles of the same side. The crescent-shaped line of insertion of the tentacles is well displayed by the two bunches on the right and left of the pillar of the main cavity; it is foreshortened in the two bunches occupying the margins of the figure. Three eyes are visible, one in the centre of the margin of the disc and one on each side, a lobe without eye-speck intervening between them. The festoon-like ramifications of the chymiferous tubes in the lobes of the margin of the disk are plainly visible, the disk being slightly contracted, in which case the margin is bent downwards. The dark ridges in the centre of the figure, terminating in sharp points, mark the outlines of the lower surface of the gelatinous disk, which is of a rich reddish brown color, and forms the roof of the main cavity of the body, exhibiting deep radiating furrows arising from an even central flat disk. Between the margin of the disk and the pillars of the digestive cavity appear the circular and the radiating folds of the lower floor of the main cavity of the body, and below the ovarian pouches and behind the tentacles hang the folds of the prolongation of the oral tentacles, which are more extensive in the genus Cyanea than in any other Medusa.

The specimen represented was an adult of ordinary size, four times larger than the figure, which may give some idea of the magnificence of such a Medusa when in full activity, with all its tentacles stretching in every direction. Specimens measuring three feet across the disk are not rare in the Bay of Boston, in September, and their tentacles may be seen trailing to a distance of ten feet in every direction from the disk. In our figure the lower ends of a large number of tentacles are cut off. When perfectly undisturbed the tentacles may be extended to an extraordinary length.

PLATE IV. represents our Cyanea from the lower surface, with different parts removed, and reproduced by themselves.

Fig. 1 may give a general idea of the relations of all the parts visible from the lower side, some of them being removed to allow the others to be seen in their natural connection with the whole. Of the four lobes extending from the four corners of the mouth, two are entirely removed, and one (s) is retained entire, its two halves d' and d''' being spread wide open to show the medial furrow leading into the digestive cavity; of the fourth (s') only one half d is preserved with the medial furrow, and the other half is cut off along the furrow. One half d of the lobe s' and one half d' of the lobe s are seen as they unite near the mouth, to show how the four lobes are separated from one another, and how their margins are folded all round. The four ovarian pouches alternate with these four lobes; but only two are preserved in this figure, one of which is almost entirely covered by the oral lobes of that side, while the other is entirely uncovered, the two oral lobes which hang to the right and left of it having been removed. It is thus seen that the sexual pouches hang down between the pillars of the corners of the mouth, and lie in the centre of a ray terminating with an eye o', each being flanked by two bunches of tentacles lying in the direction of two lobes a'' and a''', in the centre of which there are no eyes. The cavities of the sexual pouches open freely into the main cavity of the body; one of the cavities is laid open in the direction of the eye o''', the walls of the pouches being cut through near the pillars of the digestive cavity. On the opposite side, the lower floor of the main cavity is entirely removed in the direction of the lobe a', while in the direction of the lobe a the sexual pouch is alone cut off. The four oral lobes alternating with the four sexual pouches are thus seen to occupy the centre of eight rays, each of which terminates with an eye, o o o o' o'' o''', two eyes being covered by the oral lobes s and s'. These eight rays are the centres of the eight spheromeres of which a Cyanea consists. Homologically speaking, they are the eight ambulacral zones of the Cyanea. With them alternate eight interambulacral zones, a a' a'' a''', the centres of the four others being covered by a bunch of tentacles on the left side of the figure and by the oral lobes at d'' d' and d. In the centres of these eight interambulacral zones there are eight bunches of tentacles, three of which are covered by the oral lobes preserved in this figure, and one of which is entirely removed in the zone *a′*; another is cut to the base of the tentacles in the zone *a*; two others, in the zones *a″* and *a‴*, are cut very short; and one, between *o″* and *o‴*, is preserved to a greater extent. The circular folds of the lower floor are entirely preserved between the zones *o″* and *o‴* and in the zone *a*, and partially so in the zone *a″* and *o*. The radiating folds are best seen in the zones *o′ o″ o‴*, and partially in the zone *a*.

Fig. 2 represents a part of the outer surface of the lower floor in connection with the oral appendages, *a a* being the smooth membrane in the direction of the centre of the ambulacra, as seen in fig. 1, in the zones *o′ o″* and *o‴*; *b b* the radiating folds in the same zones; *c c* the radiating folds in the interambulacral zones; *d d′* and *e* the circular or concentric folds, *e* being in the ambulacral and *d* and *d′* in the interambulacral zones; 1 and 1 are the two pillars of one corner of the mouth, to the right and left of which projects a sexual pouch: at 2 these pillars unite with the horizontal and circular thickenings (3 and 4) of the oral circle, and at 5 arise the folds of the oral lobes.

Fig. 3 represents the marginal folds of the disk surrounding the eye *a b c*; *a* being the ambulacral tube of the eye, narrowed in *b*, before reaching the eye proper *e*. The whole magnified twenty-five diameters.

Fig. 4. A fold of the margin of the oral lobes magnified twelve diameters, to show the clusters of lasso-cells scattered upon their inner surface; one of these clusters is magnified 250 diameters in fig. 4a.

Fig. 5. A lobe of the margin of the disk to show the ramifications of the chymiferous tubes.

Fig. 6. The margin of the disk folded downward over the furrow in which the eye lies, to show the thickness of the gelatinous upper layer of the umbrella.

Fig. 7. A portion of the lower floor of the disk, seen from its upper or inner surface, to show how the cavity of the tentacles opens into the main cavity of the body.

Plate V. Besides many structural details relating chiefly to the tentacles, this plate represents our Cyanea as seen from above, with the margin fully expanded.

Fig. 1 gives a general view from above, the animal resting upon a dark ground. All the figures visible in this drawing are the optical expression of the unequal transparency of the gelatinous mass of the disk, through which shines the reddish-brown lining of the lower side of its upper layer. In the centre appears a tesselated, circular disk, which in adult specimens readily separates from the peripheric part. The straight rays mark the deep furrows of the lower surface, radiating from the central disk to the base of the eyes and to the middle of the interambulacral zones; the eight longer rays being the ambulacral furrows, the eight shorter ones the interambulacral furrows. The thicker bands, converging and diverging again about half-way their length, correspond to the thickenings of the gelatinous mass to which the lower floor of the disk is attached; so that by this connection of the two floors the main cavity of the body is divided into an open circular central space and sixteen radiating flat chambers, the eight narrower of which, trending in the direction of the eyes, are the ambulacral chambers, and the eight wider ones alternating with them the interambulacral chambers. Upon comparing this figure with fig. 1 of Pl. IV. it will be seen that the eight bunches of tentacles communicate with the eight interambulacral chambers; and that the four sexual pouches and the four angles of the mouth face alternate ambulacral chambers.

Fig. 2 corresponds to fig. 6 of Pl. IV., but represents the same segment of the margin of the disk from the upper side. This shows the eyes to be above the margin of the disk, as the tentacles also are.

Fig. 3 represents a band of the inner surface of the oral lobes magnified, from the margin upwards; showing that along the margin the epitheliel cells are smallest and consist chiefly of lasso-cells, fig. 3d, while higher up the lassos are in clusters, and the intervening epitheliel cells are gradually larger and larger. On the outer surface the lasso cells are few and far apart.

Fig. 4. Section of a tentacle, covered with clusters of lasso-cells, showing its inner channel and the transparent gelatinous wall. Magnified 12 diameters.

Fig. 5. Clusters of lasso-cells from the surface of a tentacle. Magnified 250 diameters.

Fig. 6. Other clusters of similar cells. Magnified 250 diams.

Figs. 7, 8, 9, and 10. Segments of tentacles, magnified 60 diameters, showing different combinations of epithelial cells and clusters of lassos. *a* indicates the central cavity of the tentacles, and *b* the band of longitudinal cells by the contraction of which the tentacles are shortened.

Figs. 11 and 12. Cells lining the cavity of the tentacles. Magnified 250 diameters.

Plate V^a. Structural details of Cyanea arctica.

Fig. 1. Transverse section of the peripheric part of one side of an ambulacrum, across the furrow for the eye. *o* furrow for the eye; *a*¹ *a*² sections of the chymiferous tubes.

Fig. 2. Transverse section of the same ambulacrum, farther from the margin of the disk, across the peripheric end of the radiating folds of the lower floor. *o* lower floor; *o*¹ ambulacral chamber; *b* radiating folds of the lower floor; *a*² section of the chymiferous tubes.

Fig. 3. Transverse section of the same ambulacrum, across the middle of the radiating folds of the lower floor and extending to the centre of the adjoining interambulacrum. *o*¹ ambulacral chamber; *b* radiating folds of the ambulacrum; *c* radiating folds of the adjoining interambulacrum; *f* tentacles of the adjoining interambulacrum; *a*¹ interambulacral chamber; *a*² chymiferous tubes of the adjoining interambulacrum; *g* thickness of the upper floor; *o* lower floor.

Fig. 4. Transverse section of the same ambulacrum, across the region where the concentric folds of the lower floor occur. *o*¹ ambulacral chamber; *a*¹ interambulacral chamber of the adjoining interambulacrum; *e* lower floor of the ambulacrum with concentric folds; *e*¹ lower floor of the interambulacrum with concentric folds; *g* thickness of the upper floor. The isthmus between the two corresponds to the broad radiating bands of fig. 1, Pl. V.

Fig. 5. Transverse section of an interambulacrum, in the region where the concentric folds occur. *g* upper floor; *a* lower floor of the interambulacrum; *o* lower floor of the adjoining ambulacrum; *a*¹ interambulacral chamber; *o*¹ ambulacral chamber of the adjoining ambulacrum; *e* and *e*¹ folds of the lower floor of the ambulacrum and of the interambulacrum.

Fig. 6. Transverse section of the same interambulacrum, across the tentacles. *a*¹ interambulacral chamber; *b* radiating folds of the adjoining ambulacrum; *c* radiating folds of the interambulacrum; *e*¹ lower floor of the interambulacrum; *f*¹ openings of the cavities of the tentacles; *f* tentacles; *g g* upper floor.

Fig. 7. Longitudinal section of an ambulacrum. *o* eye; *o*¹ ambulacral chamber; *e* concentric folds of the lower floor; *g* upper floor.

Fig. 8. Longitudinal section of the ocular chymiferous tube. *o* eye; *o*¹ peripheric prolongation of the ambulacral chamber or chymiferous tube of the eye.

Fig. 9. Transverse section of part of the upper floor, at a little distance from the central circular disk. *o* ambulacral furrow leading into an ambulacral chamber; *a* interambulacral furrow leading into an interambulacral chamber.

Fig. 10. Transverse section of part of the upper floor, near the central circular disk. *o* beginning of the ambulacral furrow; *a a* beginning of two adjoining interambulacral furrows.

Fig. 11. Transverse section of a marginal lobe of the disk, corresponding to the left part of fig. 1. *g g* upper floor; *o o* lower floor; *a*² *a*² chymiferous tubes.

Fig. 12. Part of the lower floor, seen from the outer surface. *d*¹ *d*¹ concentric folds in that part of the lower floor which is detached from the upper floor; *e* concentric folds in that part of the lower floor which is united with the upper floor along the line *k*; *e*¹ radiating folds intersecting the circular or concentric folds; *c* radiating folds of an interambulacral zone; *b* radiating folds of the adjoining ambulacral zone.

Fig. 13. Longitudinal section of an interambulacrum, in the direction of *c*¹ in fig. 12. *d*¹ concentric folds corresponding to *d*¹ in fig. 12; *e*¹ concentric folds corresponding to *e*¹ in fig. 12; *f*¹ openings of the cavities of the tentacles in the prolongation of the same zone; *f* the tentacles.

Fig. 14. Transverse section across the middle of a Cyanea, to show the general relations of the upper and lower floors of the disk. The section passes through two interambulacral, and through two sexual pouches, and divides the mouth so as to leave two oral lobes entire. This figure is much reduced. *g g* upper floor; *f*¹ *f*¹ and *e e* lower floor; *f*¹ *f*¹ being the openings of the tentacles leading into the ambulacral chamber, and *e e* the concentric folds of the lower floor; *f f* tentacles; *os, os,* sexual pouches; 3 3 thickened ring of the mouth; *d d* the oral lobes; *d*⁴ *d*⁴ the marginal folds of the oral lobes.

Fig. 15 is intended to show the connection of the oral lobes with the lower floor, *e e*¹ and *d*¹ being the part of the lower floor with concentric folds. 1 is one of the pillars arising with two roots from the margin of *d*¹ to form one of the corners of the mouth, while, at the same time, supporting the lateral walls of the main cavity, 5 marking the point where the pillar divides again to form the two halves of each oral lobe, as seen in Pl. 4, fig. 1 *s*, 2 being one of the branches; 3 is the thickened ring of the mouth connecting the four pillars; under its thickest part, 4, the oral lobes bend inward to shut the mouth; *os* folds of a sexual pouch, *o o* being the sexual organs; *d d* oral lobes; *d*⁴ *d*⁴ folds of the oral lobes.

Fig. 16. Internal view of the mouth, the four pillars supporting its four corners and their prolongations into the oral lobes being cut through in different ways, so as to exhibit in different sections the varying thick-

ness of the pillars and of their prolongation. 1 1 1 1 the four pillars; *s s s s* the furrows along the middle of the lower surface of the oral lobes; *d d d* the oral lobes, meeting from below in the centre of the figure to shut the mouth; *os*, *os*, *os*, the cut edges of the sexual pouches.

Fig. 17 explains more fully the relations of the parts represented in fig. 16. 3 oral ring; 4 thickening of the oral lobe *d* bending over the mouth; *os* fold of the sexual pouch.

Fig. 18 shows how the sexual organs *of* are supported in the folds of the sexual pouch *os*.

Fig. 19 shows the connection of an oral pouch with the concentric folds e^1 of the lower floor, and, with the tentacles *t t*, connected with the sexual organs *of*.

Fig. 20. Lobes of a sexual pouch stretched out. *o* ovaries; *of* folds formed by the ovaries; *t* their tentacles.

Fig. 21. Lobes of the sexual pouch of a young female. *o* undeveloped ovary; *of* folds of the ovary; *t* their tentacles.

Fig. 22. Lobes of a sexual pouch of a male stretched out. *os* folds of the pouch passing into the concentric folds of the lower floor; *s* spermatic cells; *sf* folds of the spermatic sacs; *t* their tentacles.

Fig. 23. Part of the lower floor, embracing one entire ambulacrum *o* and one entire interambulacrum *a*, with one half of the adjoining ambulacrum and interambulacrum, to show the inequality of the width of the ambulacral, *e*, and of the interambulacral, e^1, chambers, *k k* being the gelatinous bands along which the upper and lower floors are united; *f* the tentacles, and d^1 the point where the folded part of the lower floor passes into the folds of the sexual pouches and into the pillars of the digestive cavity.

Fig. 24. Ramifications of the chymiferous channels along the margin of the disk. *c* tube of the eye; *o* lobe of the eye; *a* interambulacral incision; a^1 a^2 interambulacral lobes; o^1 and o^2 ambulacral lobes. The parts in black correspond to the parts in white of fig. 23, the channels being kept light in fig. 24 and dark in fig. 23, having been drawn upon different grounds.

PLATES VI., VII., VIII., and IX.

AURELIA FLAVIDULA, *Pér.* and *LeS.*

[All the figures of these plates were drawn from nature by A. Sonrel.]

PLATE VI. represents our Aurelia from below, with sundry details.

Fig. 1. When the disk is fully expanded, and the appendages of the lower side are in their natural position, several features appear in this species, which seem not to have been noticed in other allied Acalephs. The mouth is closed by folds of the oral lobes, and one of these folds forms a transverse ridge across the oral aperture. The oral lobes, or so-called arms, are not stretched out at the same angles with one another, but stand nearer each other on opposite sides in one direction than in the other. In the ramifications of the chymiferous system it should also be noticed, that, of the sixteen simple radiating tubes, eight reach the base of an ocular apparatus, and eight others, alternating with them, anastomose with the marginal circular tube without branching.

Fig. 2. Segment of the same, the margin being arched downward. This figure shows that during the contractions of the disk *r r*, the oral lobes are not projected beyond its margin, but are bent along the furrow formed by the curve, and the tentacles, *b*, thrown out. *o o* eyes; *d d* chymiferous tubes; *a a* folds of the oral lobes or arms; *e* their stem; *i* opening leading into a blind sac below the sexual pouch (this opening is generally but falsely represented as leading into the sexual cavity and communicating with the main cavity).

Fig. 3. Oral opening laid open by the reversion of the oral lobes a^1 a^2 a^3, *a* remaining in place. *o* pyramid of the centre of the disk projecting into the oral aperture, which exhibits eight emarginations, four, *i i*, in the angles corresponding to the base of the stems of the oral lobes, and four, *c e*, in the direction of the sexual pouches.

Fig. 4. Eye, as seen facing the margin of the disk where this is curved down. *o* eye; *c c* ocular lobes of the margin of the disk; *e e*, *i i* chymiferous tubes of the ocular apparatus.

Fig. 5. Transverse section of the oral arm of a male individual, showing how much thinner its stem is than that of the female, fig. 6. *a* stem of the oral lobes; *b* and *c* its two halves spreading to form the folds or lobes, *e e*, of the arms.

Fig. 6. Transverse section of the oral arm of a female individual. *a* stem; *b c* its halves; *e e* the folds or lobes in the pouches of which the eggs are received and remain until the young is freed to swim about.

PLATE VII. General view of Aurelia flavidula from above, with structural details.

Fig. 1. View of our Aurelia from above, in which the ovaries appear plainly through the transparent disk,

and the oral arms are faintly visible below. This figure shows distinctly, that in four directions the chymiferous tubes arise directly from the main cavity, and in four other directions, alternating with the former, they arise from the peripheric side of the sexual pouches.

Fig. 2. Magnified view of the margin of the disk, seen from below, to show the origin of the tentacles *a a*, between the lobules of the margin *b b b*, the veil *c* extending along the under side. *d* represents a chymiferous tube.

Fig. 3. View of the same from above, more highly magnified, showing the clusters of lasso-cells scattered over the upper surface. *a a* tentacles; *b b* lobules of the margin; *c* circular marginal chymiferous tube; *d d* radiating chymiferous tubes.

Fig. 4. Longitudinal section of the margin of the disk, the better to show the relations of the tentacles *a a a*, and the marginal lobules *b b*.

Fig. 5. View of the centre of the disk from below, the oral appendages being removed. *o* pyramidal projection of the centre of the disk; *a b c* radiating chymiferous tubes arising directly from the main cavity of the body; *d d d* radiating chymiferous tubes arising from the peripheric side of the sexual pouches, one of which, *e*, is laid open by the removal of its lower floor, while in the others the floor is preserved; *i* indicates the arch over the opening leading into the blind sac which extends below the sexual pouches. This opening is generally represented as leading into the sexual pouches, but this is not the case; the arch *i* supports a thin vein which separates the sexual pouches from the blind sacs below.

Fig. 6. Top of a tentacle, magnified. *e* its cavity; *a* epithelial layer covering its surface.

Fig. 7. Termination of one of the oral appendages or arms with its marginal fringes *b*, *b*; the channel *a* extends along its middle from the tip of the marginal lobes to the main cavity of the body.

PLATE VIII. Profile view of our Aurelia with structural details.

Fig. 1. Profile view, in a state of contraction of the disk, when the oral appendages appear inclosed in the cavity thus formed, and the sexual pouches are seen in profile, exhibiting distinctly the wreath formed by the sexual organs, as well as the origin of the chymiferous tubes arising from the margin of the sexual pouches.

Fig. 2. Transverse section of the margin of the disk, to show the difference of thickness of the upper and lower floors *a* and *c*, with the chymiferous tubes *b b'*, formed by the union of the two.

Fig. 3. Similar section, magnified. *a* upper floor; *c* lower floor; *b* line of separation between the upper and lower floors; *b'* chymiferous tube formed by the recession of the upper and lower floors; *d* lower surface of the lower floor.

Fig. 4. Upper surface of the upper floor magnified, to show the clusters of lasso-cells scattered over it.

Fig. 5. Transverse section of the margin of the disk, which, in connection with fig. 4 of Pl. VII., may fully explain the relations of all the parts there combined. *a* opening of the marginal circular chymiferous tube; *e* the tube itself; *b* section of the veil extending along the lower surface; *c* part of the veil itself; *d d* tentacles; *d'* cavity of one of the tentacles; *f* radiating chymiferous tube, opening into the circular tube of the margin; *f'* another radiating tube cut through in the section, in which *h* marks the upper floor, and *g* the lower surface of the lower floor.

Fig. 6. Magnified tentacles to show their connection with the circular marginal tube. *d* tentacle; *d' d'* cavity of the tentacles; *c c* marginal tube into which the tentacles open.

Fig. 7. Lobes of the ovary with their tentacles. *a* folds of the sexual pouch; *b b* ovarian lobes; *c c* tentacles of the ovarian folds.

Fig. 8. An ovarian lobe, stretched out to show that the folds of the sexual pouches surround the sexual organ on both sides. *a a* folds of the pouch; *b b* ovarian lobes stretched; *c c* tentacles of the ovarian folds.

Fig. 9. Margin of the oral lobes, in the depressions of which the eggs and planulæ are received, magnified. *a a a* clusters of eggs and planulæ in different stages of development, gathered in the sac-like depressions of the margin of the oral lobes, where they remain until they are capable of living independently of their parent; *b b* the fringes or tentacles of the margin of the oral lobes, adapted to seize upon the prey.

PLATE IX. Structural details of our Aurelia.

Fig. 1. Spermarian lobes stretched out, magnified sixty diams. *b b* spermaries; *c c* tentacles of the spermaries.

Fig. 2. Several spermarian lobes, less extended, magnified 12 diams. *b b* spermaries; *c c* tentacles of the spermarian folds.

Fig. 3. Eye, with its chymiferous tubes and the tentacles on its sides. *o* eye; *c c* marginal circular tube, from which arise the tentacle-like tubes *i*, *i'*, *c*; *f f f* radiating chymiferous tubes; *d' d'* tentacles opening into the marginal tube.

Fig. 4. Eye, with a larger part of its surroundings. *o* eye; *e e e* marginal circular tube; *c c* outer tubes; *i i* marginal folds inclosing the ocular apparatus; *f f f* radiating chymiferous tubes; *d d d* tentacles.

To understand correctly the sections represented in figs. 5, 6, 7, 8, and 9, the direction in which they are cut should be first ascertained by a comparison with figs. 1, Pl. VI. and VII. Section 5 runs from the centre, between two ovarian pouches, to the margin of the disk. If it were prolonged across the whole animal, it would divide fig. 1 of Pl. VI. and VII. into halves; and the part represented corresponds to the right side of the upper half, the tube running between the bisected arm *b* and the ovary *r*, along the lower surface of the disk, being one of the chymiferous tubes which arise from the main cavity of the body. Figs. 7, 8, and 9 also pass through the centre of the disk, but extend through the centres of two opposite ovarian pouches, that is, they run at an angle of 45° with the section fig. 5, or obliquely across fig. 1 of Pls. VI. and VII. In fig. 7, the central pyramid of the disk is removed to show more plainly the mode of communication of the ovarian pouch *n p*, with the central cavity of the body *s*; and, to bring these relations more plainly into view, the left ovarian pouch is also removed, and in the right ovarian pouch the veil which separates the pouch from the blind sac below is removed with the ovaries themselves, while in figs. 8 and 9 they are left in place. Fig. 9 corresponds to fig. 8, except that fig. 8 passes through the centre of the pouch and shows the cavity from one side and fig. 9 from the opposite side, the section passing somewhat obliquely through the pouch. Fig. 6 is a transverse section across an ovarian pouch from side to side of the pouch, and not, like all the others, radiating from the centre to the periphery.

Fig. 5. Section across the disk, including the centre and one side. *o* pyramid of the centre; *p* veil forming the lower floor of the sexual pouch; *q* channel leading from the central cavity into the sexual pouch; *r* sexual organ; *n* sexual pouch; *s* central cavity; *a a* oral lobe; *b* its stem cut through; *c c* its marginal folds; *m m* upper floor or gelatinous mass of the disk.

Fig. 6. Sexual pouch, seen from the side opposite its communication with the central cavity. *d d* lower floor of the disk; *p* arch of the veil *p*¹, which separates the sexual cavity *n*, in which the sexual organs *r r* are inclosed, from the blind sac *f*, which is below and communicates through the hole *f* with the surrounding medium.

Fig. 7. Another section through the centre of the disk, across two opposite ovarian pouches, leaving one, in the centre of the figure, entire in the distance. *s* central cavity; *a a* oral appendages or arms; *b b* stems of the oral appendages cut through; *c c* marginal folds of the arms; *d* and *e* the thickened pillars in the lower floor surrounding the hole *f*, below the sexual cavity; *r r* sexual organs; *p* veil forming the lower floor of the sexual pouches; *n* sexual cavity; *m m* upper floor.

Fig. 8. Another section passing through a sexual pouch. *o* pyramid of the centre of the disk; *s* central cavity of the body; *a* oral appendage or arm, cut through at *b*; *c c* its marginal fringes; *d* and *e* lower floor thickened and inclosing the blind sac *f*; *q* channel leading from the main cavity into the sexual pouch *n*; *r* sexual organ; *p*¹ veil separating the sexual pouch from the blind sac below; *m m* upper floor.

Fig. 9. Another section, passing somewhat obliquely through a sexual pouch. *a* arm, cut through at *b*; *d* and *e* thickened lower floor, surrounding the blind sac *f*; *o* pyramid of the centre of the disk; *s* main cavity; *q* channel leading into the ovarian pouch; *p* veil separating the ovarian pouch from the blind sac below; *p*¹ section of the veil; *r r* sexual organ; *n n* sexual pouch; *m m* upper floor of the disk.

PLATE X.

Scyphostoma of Cyanea arctica and Aurelia flavidula.

[Figs. 18, 23, 31, 32, and 30, Aurelia flavidula, were drawn by A. Sonrel; the others, Cyanea arctica, by H. J. Clark.]

Figs. 1 and 2. Eggs from the ovary of Cyanea arctica, Sept. 28, 1857, magnified 500 diameters.—*v* vitelline sac; *y y*¹ yolk; *p* Purkinjean vesicle; *w* Wagnerian vesicle.

In all the remaining figures, 3 to 38, the following letters refer to the same parts. *a* the outer wall of the body; *a*¹ the outer wall of the tentacle; *b* the inner wall of the body; *c* the mouth or proboscis; *c*¹ the basal or posterior end; *d* the digestive cavity; *e e*¹ the tentacles; *f*¹ the base of the horn-like sheath or tube.

Fig. 3. A globular embryo, just escaped from the pouches. Magnified 500 diameters.

Fig. 4. Profile view of an ovate embryo just from the pouches. 500 diameters.

Fig. 4a. View of the broad end of fig. 4.

Fig. 5. Profile of a cylindrical embryo. 200 diams.

Fig. 5a. End view of fig. 5.

Fig. 6. One of the smaller forms of cylindrical embryos. 200 diameters.

Fig. 7. Profile of an embryo, swimming with the clear space (*d*) behind. 200 diameters.

Fig. 7a. End view of the darker end of fig. 7.

Fig. 8. In this embryo the clear space (*d*) is very large. 200 diameters.

Fig. 8a. The same as fig. 8, contracted, and the clear space obliterated.

Fig. 9. View of the flat side of an oval, concave, disciform embryo. 200 diameters.

Fig. 9a. Edge view of fig. 9, showing the double concave sides.

Fig. 10. View of the flat side of an ovate, compressed embryo. 200 diameters.

Fig. 10a. Edge view of fig. 10.

Fig. 10b. Broader end of fig. 10.

Fig. 10c. Narrower end of fig. 10; the cilia are reversed by the embryo.

Fig. 10d. The mouth of fig. 10; the cilia are quiet, and look like bristles. 500 diameters.

Fig. 11. An irregularly ovate, cylindrical embryo, recently attached to a sea-weed, the tentacles (*e*) just beginning to bud. The vibratile cilia do not move any more, and have begun to decompose. 200 diameters.

Fig. 12. A scyphostoma with an incipient horn-like sheath. The cilia are quiet and decomposing. 200 diameters.

Fig. 12a. View of the actinal end of fig. 12.

Fig. 13. A scyphostoma with two incipient tentacles; the cilia are still persistent but immovable. 200 diams.

Fig. 13a. Actinal end of fig. 13.

Fig. 14. A scyphostoma with four young tentacles and a narrow base, but no horn-like sheath. 200 diams.

Fig. 14a. The same as fig. 14, with the mouth very wide open.

Fig. 14b. View of actinal end of fig. 14, showing the asymmetrical development of the tentacles (*e*).

Fig. 14c. The same as fig. 14, with the mouth (*c*) enormously distended, and the tentacles so completely retracted as to be undiscernible.

Fig. 15. An abnormally developed scyphostoma. 100 diameters.

Fig. 16. Another form of abnormal development. 100 diameters.

Fig. 16a. Actinal end of fig. 16.

Fig. 17. Actinal end of an individual with three tentacles. 100 diameters.

Fig. 18. Similar to fig. 17, but a little older. 100 diams.

Fig. 19. A profile view of a scyphostoma with four tentacles, which are only half extended, and the proboscis retracted. 200 diameters.

Fig. 20. Similar to fig. 19, but the tentacles and base more extended. 100 diameters.

Fig. 21. Similar to figs. 19 and 20. One of the tentacles has seized upon a wandering embryo, and is drawing it toward its mouth. 100 diameters.

Fig. 22. Actinal end of an individual similar to figs. 19, 20, and 21. 100 diameters.

Fig. 23. Actinal end, with two double tentacles; the proboscis as in fig. 16, but foreshortened. 100 diams.

Fig. 24. Actinal end, with four unequally developed tentacles. 100 diameters.

Fig. 25. Actinal end, with three incipient tentacles (*e*) of the second group; the quadrangular mouth is distorted. 100 diameters.

Fig. 26. Three quarters view of a scyphostoma, with a quinary development of tentacles, and a very large proboscis. 100 diameters.

Fig. 27. Actinal end, with one tentacle, of the second group, unduly developed. 100 diameters.

Fig. 28. Actinal end, with three double tentacles. 100 diameters.

Fig. 29. Actinal end, with a three-cornered mouth. 100 diameters.

Fig. 30. Actinal end, showing a captured embryo revolving in the digestive cavity. 100 diameters.

Fig. 31. Profile view of an individual similar to fig. 30, with the tentacles and base fully extended. 100 diams.

Fig. 32. Actinal end, the mouth rounded and one tentacle forked. 100 diameters.

Fig. 33. Profile, with eight tentacles, a slender base, and the corners of the lips prominent. 100 diameters.

Fig. 34. Three quarters view, with eight well developed tentacles. The outer and inner walls are made prominent. 100 diameters.

Fig. 34a. Actinal end of fig. 34, with the tentacles retracted to mere papillæ, and the mouth shaped into an eight-sided figure. 100 diameters.

Fig. 34b. Actinal end of fig. 34, with tentacles retracted and curled inwardly.

Fig. 35. Profile view, with eight tentacles, one of which is drawing the excrementitious matter from the open proboscis.

Fig. 36. Actinal end, similar to fig. 34, but the mouth contracted to a small oval aperture and the tentacles partly retracted and curled inwardly. 100 diameters.

Fig. 37. Profile of a double-headed scyphostoma, with

eight tentacles on one head and only four on the other. 100 diameters.

Fig. 37a. The same as fig. 37, with the tentacles retracted.

Fig. 38. A forked tentacle. 100 diameters.

PLATE Xa.

Scyphostoma of Cyanea arctica and Aurelia flavidula, etc.

[Figs. 1, 2, 3, 4, 4a, 5, 6, 7, 8, 10, 11, 12, 12a, 14, and 15 are drawn by H. J. Clark; figs. 4b, 9, 13, 15a, 16 to 41, by A. Sonrel.]

All the figures by H. J. Clark, and fig. 9, are Cyanea arctica; and all those by A. Sonrel, excepting fig. 9, are Aurelia flavidula. Unless when stated otherwise, the following letters refer to the same parts: *a* outer wall of the body; a^1 outer wall of the tentacle; a^2 lasso-cells; a^3 end of the tentacle; *b* inner wall of the body; b^1 inner wall of the tentacle; b^2 radiating partition in the body; b^3 transverse wall of the cells in the axis of the tentacle; *c* mouth; c^3 proboscis; c^1 base of the body; *d* digestive cavity; *e* e^1 tentacles; *f*, horn-like sheath; *p*, Purkinjean vesicle; *w*, Wagnerian vesicle; *y*, yolk.

Fig. 1. The mouth and one tentacle of an eight-armed scyphostoma. 500 diameters.

Fig. 2. Partially retracted tentacle of a four-armed scyphostoma. 500 diameters.

Fig. 3. Contracted tentacle of an eight-armed scyphostoma. 500 diameters.

Fig. 4. An eight-armed scyphostoma, showing the strongly contracted tentacles, the mouth wide open, and the horn-like sheath. 200 diameters.

Fig. 4a. Base of fig. 4, to show the details of the horn-like sheath. 500 diameters.

Fig. 4b. Similar to fig. 4, but the tentacles only partly retracted. 200 diameters.

Fig. 5. Actinal end of an eight-armed scyphostoma to show the details of the mouth, radiating partitions, etc. 200 diams. The arrangement of the cells around the mouth and along the tentacles shows an unmistakable resemblance to the plates forming the borders of the corresponding parts in Echinoderms, and especially in Star-fishes.

Fig. 6. Basal portion of fig. 20, Pl. X., to show the cellular structure of the walls. a^1 outer surface of the outer wall (*a*); b^1 outer surface of inner wall (*b*). 500 diameters.

Fig. 7. Tentacle of fig. 14, Pl. X., to show the lasso-cells. 500 diameters.

Fig. 8. Cells from the inner surface of the inner wall of fig. 14c, Pl. X. 500 diameters.

Fig. 9. A to G lasso-cells of a full-grown Cyanea. *a* the wall of the cell; *b* the coil. 500 diameters.

Fig. 10. Lasso-cells from the tentacle of Fig. 14, Pl. X. 500 diameters.

Fig. 11. The second set of tentacles half developed, and two of the first set forked. 100 diameters.

Fig. 12. Shows one hydra fixed temporarily in the mouth of another. 100 diameters.

Fig. 12a. Actinal end of A, fig. 12.

Fig. 13. The third set of tentacles partially developed. b^3 intervals between the radiating partitions (b^2). 100 diameters.

Fig. 14. Actinal end of a scyphostoma with ten tentacles, developed in fives, and the mouth five-sided. 100 diams.

Fig. 15. Actinal end of a scyphostoma with fourteen tentacles, in various stages of growth; the numbers refer to their relative ages. 100 diameters.

Fig. 15a. Similar to fig. 15, but very much contracted.

Figs. 16 to 24. The serial development of the egg; taken from the ovary of a full-grown Aurelia. 200 diams.

Figs. 25 to 36. The progressive development of the free scyphostoma planula of Aurelia. Figs. 26, 27, 28, 30, 31, and 32 from the ovary; figs. 25, 29, 33, 34, 35, and 36 from the pouches. 200 diameters.

Fig. 37. The proboscis and sexual organs (*e*) of fig. 22, Pl. XIa. *a* lips; a^1 incipient fringes of the edge of the proboscis; *d* aperture of the mouth. 20 diams.

Figs. 39, 40, and 41. Details of the proboscis of fig. 37, with the same letters.

PLATE XI.

Strobila of Aurelia flavidula.

[Drawn by A. Sonrel.]

Unless otherwise stated, all the figures are magnified 15 diameters. In all the figures of Plates XI., XIa., XIb., and XIc., the following letters refer to the same parts, unless otherwise stated.

For the scyphostoma, *c* is the mouth or proboscis; c^1 base of body; c^2 c^3 c^4 offshoots from the body; *d* digestive cavity; *e* e^1 tentacles; *g* g^1 g^2 g^3 g^4 g^5 constrictions preparatory to the formation of the saucer-shaped disks.

For the ephyra, *a* is the proboscis; a^1 the mouth or lip; a^2 the cavity of *a*; *b* the digestive cavity; b^1 limit of *b*; *c* chymiferous canal leading to the eyes; c^1 c^2 branch of

c; c^3 entrance to c; c^4 end of c; c^5 chymiferous canal in the peduncle of the eye; d ridge of c; d^1 fork of d; d^2 floor of c; e chymiferous canal to the tentacles; e^1 lateral branch of e; e^2 inner wall; e^3 entrance to e; f ridge of e; g sexual appendages; g^1 common opening of g; g^2 second row of appendages; g^3 common opening of g^2; g^4 exterior pouch; h eye; h^1 outer wall of h; h^2 inner wall of h; h^3 base of h; h^4 facets of eyes; h^5 base of h above; h^6 base of facet h^4; h^7 centre of h; h^8 lateral base of h; i i^1 veil; i^2 marginal lobules; i^3 tentacle, or tentacular lobe; i^4 inner wall above; i^5 inner wall below; i^6 outer wall above; i^7 outer wall below; i^8 lower side of the veil; i^9 edge of the disk; j oculiferous lobe; j^1 lappets of j; j^2 ridge of j^1; j^3 ridge in transverse section; j^4 back of the lappet; j^5 edge of j above; j^6 outer wall above; j^7 inner wall above; j^8 inner wall below; j^9 outer wall below; k partitions between canals; k^1 partially isolated partition; k^2 an insular partition; l the disk; l^1 axis of the strobila; l^2 axis of the disk; m muscular ring, inner edge; m^1 outer edge of m; mc marginal canal; aj edge of lobe j, below; bj commsisure of lappets j^1; cj depression at the base of bj; dj fold of the lappet below.

Fig. 1. The lowest ephyræ of a strobila which has already lost the upper ones, ready to drop; they are drawn here whilst in the systole of one of their convulsive contractions, by which they break loose, and the remains of the scyphostoma has its fully developed tentacles extended to the utmost.

Fig. 2. The remains of a scyphostoma, showing the offshoots.

Fig. 3. Another old scyphostoma, with a few distorted ephyræ.

Fig. 4. An old scyphostoma, with distorted tentacles, and a few nearly mature ephyræ.

Fig. 5. The base of a column of ephyræ, and a scyphostoma with eye spots, h, at the base of the tentacles.

Fig. 6. A scyphostoma, with its second row of tentacles, bearing a column of thirteen ephyræ in various stages of development.

Fig. 7. A scyphostoma with twenty tentacles, probably belonging to the second group formed after the fall of the ephyræ.

Fig. 7a. Proboscis of fig. 7. 20 diameters.

Fig. 8. Interior view of the edge of the ephyra of fig. 14. 30 diameters.

Fig. 9. The plicated lip of the proboscis of fig. 13 l. 30 diameters.

Fig. 10. A young strobila, still incomplete; the terminal ephyra has the deciduous false tentacles.

Fig. 11. A strobila casting its last ephyra.

Fig. 12. The base of a double strobila, formed by transverse division of the discs B and C.

Fig. 13. The last ephyra just ready to drop.

Fig. 14. The last and youngest of a pile of ephyra, bearing sixteen deciduous, false tentacles.

Fig. 15. An incipient pile of ephyræ, the terminal one bearing sixteen deciduous tentacles.

Fig. 16. An old strobila, the terminal ephyra bearing sixteen deciduous tentacles, and the scyphostoma having two rows of tentacles.

Fig. 17. The three oldest ephyræ are nearly mature, whilst the fourth is far behind in age.

Fig. 18. An old scyphostoma with three rows of tentacles.

Fig. 19. The terminal ephyra shows the homologies between the tentacles of the scyphostoma and the oculiferous lobes and eye-peduncles of the ephyra.

Fig. 20. One of the ephyræ of fig. 10.

Fig. 21. Scyphostoma-like ephyræ, similar to figs. 18 and 19.

Fig. 22. A form combining the features of fig. 15 and fig. 21.

Fig. 23. A double oculiferous lobe from an ephyra of fig. 29. 30 diameters.

Fig. 24. A portion of the disk of one of the ephyræ of fig. 29. 20 diameters.

Fig. 25. A mass of monstrosities both of the ephyræ and scyphostoma.

Fig. 26. Proboscis and sexual appendages of fig. 11, 1.

There is no fig. 27. It was omitted in numbering the plate.

Fig. 28. A terminal ephyra with branching deciduous tentacles.

Fig. 29. Shows an ephyra just escaping from its axial attachment, which passes into the proboscis of the next lower individual.

PLATE XIa.

Scyphostoma and Ephyra of Aurelia flavidula.

[All the figures drawn from nature by A. Sonrel.]

Unless when otherwise stated, the figures are magnified 15 diameters. For the lettering, see Pl. XI.

Fig. 1. An old scyphostoma attached by a lateral process of its base.

Fig. 2. A scyphostoma-like process (c^3) budding from the base of an old scyphostoma. 20 diameters.

Fig. 3. Two scyphostomas arising from a common basis. 20 diameters.

Fig. 4. An old scyphostoma, with large offshoots.

Fig. 5. Similar to fig. 4, with one rigid-looking offshoot.

Fig. 6. A scyphostoma bearing an offshoot with a globular tip.

Fig. 7. A longitudinally ridged scyphostoma with a distorted offshoot.

Fig. 8. Here the offshoot is forked (c^3 c^3).

Fig. 9. The offshoots are remarkably long and tentacular.

Fig. 10. A strobila just making its first constriction.

Fig. 11. A strobila with two constrictions.

Fig. 12. A deformed strobila.

Fig. 13. Two of the disks are well formed, but not mature.

Figs. 14 and 15. A foreshortened and a three-quarters view of the proboscis of fig. 19. *d* aperture of the mouth; *e* the sexual appendages. 20 diameters.

Figs. 16 and 17. Various attitudes of the proboscis of fig. 26. *a* the cruciate aperture; a^1 lip; *d* cavity of the proboscis; *e* sexual organs. 20 diameters.

Fig. 18. More highly magnified view of the proboscis of fig. 19. *a* cruciate fold of the lips a^1; *b* outline of the proboscis, in the distance; *c* inner surface of the folds of the aperture *d*; *e* sexual appendages. 60 diameters.

Fig. 19. Lower side of an ephyra, a short time after it became free. The broad radiating canals *d* and *e* occupy as much space as the intervals. 10 diams.

Fig. 20. Upper side of fig. 19 when it is in a contracted state.

Fig. 21. Same as figs. 19 and 20 when the umbrella is reverted.

Fig. 22. Profile view of an ephyra, which has the corners (a^1) of the lips and the veil (i^1) very prominently developed; i^3 the tentacular lobe. 10 diameters.

Fig. 23. Same as fig. 20 in profile. 5 diameters.

Fig. 24. Another reverted form of fig. 19.

Fig. 25. Upper surface of an ephyra a little younger than fig. 22. The branching lines are dorsal folds in the canals. 10 diameters.

Fig. 26. Upper side of an ephyra, which is a little younger than fig. 25. About 15 diameters.

Fig. 27. A three-quarters dorsal view of fig. 19 in a reverted or diastolic state. 5 diameters.

Fig. 28. Profile of fig. 19 in the diastole.

Fig. 29. Portion of the edge of an ephyra, bearing several tentacles and having an incipient lacunar branching of the canals.

Fig. 30. Same as fig. 25, in a contracted state.

Fig. 31. Oculiferous lobe of fig. 19, lower side. 20 diameters.

Fig. 32. Dorsal view of fig. 22 in a contracted state.

Fig. 33. Foreshortened view of fig. 31.

Fig. 34. Eye peduncle of fig. 31. 60 diameters.

Fig. 35. Cells from the upper surface of the lappet of the oculiferous lobe of fig. 25. *l* lasso-cells. 470 diams.

PLATE XI^b.

Ephyra of Aurelia flavidula.

[Drawn from nature by H. J. Clark.]

Figs. 1 and 2, from an ephyra a little younger than that of fig. 19, Pl. XI^a.

Fig. 1. The incipient sexual organ, seen from below, with two rows of digitate appendages, the longer ones (*g*) seen beyond the shorter. 100 diameters.

Fig. 2. The edge of the disc, seen from below, between two oculiferous lobes, bearing a single budding tentacle (i^3) and a tongue-shaped veil. 100 diameters.

Fig. 3. Similar to fig. 2 but older, and belonging to fig. 4. The principal feature is the incipient folding of the tentacular lobules i^3. 100 diameters.

Fig. 4. Inferior view, from centre to margin, including one of the oculiferous lobes and the two veils on each side, of an ephyra in which the radiating canals have begun to branch; a single tentacle has developed, and the veil is half as long as the oculiferous lobes. 40 diameters.

Fig. 5. Profile of an ephyra with thirty-two tentacles at every interval. The disk is contracted; the same as fig. 20. Natural size. See Pl. XI^c. fig. 5.

Fig. 6. Shows the vibratile cilia on the inner surface of the proboscis of fig. 5. 500 diameters.

Fig. 7. The eye and eye peduncle of fig. 4, seen from below, to show the relation of the layer of the lenticular bodies of the eye to the walls. 500 diameters.

Fig. 8. Longitudinal sectional view of the eye of fig. 7, showing that the lenses are in the inner wall.

Fig. 9. Longitudinal section of fig. 3, to show the relations of the walls of the upper and lower floors. 100 diameters.

Fig. 10. The sexual organ, with several rows of digitate appendages, from figs. 17 and 18. View from below. 100 diameters.

Fig. 11. One of the crystalline lenses of fig. 7, seen from the flat or inner end, showing its polyhedral outline and the branching cavity. *α* the wall of the cell which belongs to the outer wall of the peduncle and overlies the cell which contains the lens; it is seen in the distance (see *α* fig. 16); *δ* the flat side of the prism foreshortened, and as the outer end is broader than the inner, the outline of the latter is concentric to that of the former; *θ* the solid part of the lens, to compare with *θ* in fig. 16; *ι* to compare with *ι* in fig. 16; *μ* the diverticuli from the cavity *ν*, in the centre. 2,000 diameters.

Fig. 12. One of the lappets of an oculiferous lobe of fig. 4, curved downwards, so as to give a sectional view of its thickness, and to show the keel. 100 diameters.

Fig. 13. Transverse section of the simple radiating canal ($c\ c^1$ fig. 17), and the two canals on each side which come from the forked canal (*c*, fig. 17); *α*, *β*, groups of long-drawn-out cells, remnants of the attachment of the superposed walls. 100 diameters.

Fig. 14. End view of the so-called eye-speck *h*, fig. 7. 500 diameters.

Fig. 15. Profile and sectional view of fig. 7. 300 diameters.

Fig. 16. Shows the position of the crystalline lenses in the cells of the inner wall of the ocular peduncle. *α* a superposed cell of the outer wall (see fig. 11 *α*); *β* the wall of *α* where it rests on the outer end, *δ*, of the underlying cell; *γ* the clear, homogeneous contents of *α*; *δ* the outer end of the lens-bearing cell; *ε* the cavity of *η* in front of the lens; *ζ* the inner end or bottom of *η*; *θ* the side of the prism receding from the eye; *ι* the side of the prism nearest the eye; *κ* the rounded anterior surface of the lens; *λ* the cylindrical axial cavity of the lens; *μ* the canals radiating from *λ* and following close to the flat posterior face of the lens; *ν* posterior opening of *λ*. 2,000 diameters.

Fig. 16ᵃ. A lasso-cell from fig. 7. *a* the cell wall; *b* the aperture of the cell and base of the thread; *c* the end of the thread; *d* point of junction between the straight axial portion and the coils of the thread; *e* the first coil of the spiral; *f* the transversely spiral coils. 2,000 diameters.

Fig. 17. A quarter part of the disk of fig. 18, seen from below. There are fourteen tentacles. The branching radiating canals are nearly or altogether six pronged, and the edge of the disk occupies two thirds of the circumference. 40 diameters. Next the oculiferous lobe on the right, the veil and the tentacles are curved downwards and inwards.

Fig. 18. An ephyra, seen from below. Natural size.

Fig. 19. One of the marginal fringes of fig. 6, Pl. XIᶜ. *a* the end, where the wall is thickened and contains numerous lasso-cells; *b* group of lasso-cells; *c* the same as *b* in profile. 200 diameters.

Fig. 20. Profile of an ephyra, with the disk expanded, the same as fig. 5. Natural size. (See Pl. XIᶜ. fig. 5.)

Fig. 21. One of the digitate bodies of fig. 18 *c*, Pl. XIᵃ. *α* the single wall studded with lasso-cells; *β* the inner wall of the lower floor from which *α* arises; *γ* the entrance to *α*. 300 diameters.

PLATE XIᶜ.

Aurelia flavidula (ephyra) and Coryne mirabilis.

[Drawn from nature by H. J. Clark.]

For the general lettering, see description of Pl. XI.

Fig. 1. A tentacle from the edge of the disk of fig. 9. $a\ a^1\ a^2$ the outer wall, seen in a sectional view (*a*) near the end of the tentacle, in a surface view (a^1), and again in section where it is very thick (a^2) and contains a group of lasso-cells, and finally where it is stretched so as to be very thin (a^3); *b* the inner wall near the end of the tentacle; b^1 seen through a^1, in a sectional view (b^2) underneath a group of lasso-cells, and extremely extended (b^3) like a^3; *c* the end of the tentacle in section, crowded with lasso-cells; c^1 a group of lasso-cells in section; *d d* the channel extending from base to tip directly from the circular canal; *e* groups of lasso-cells. 500 diameters.

Fig. 2. View from above of the eye and the immediately surrounding parts of the disk, from an ephyra an inch and a half in diameter and having fifty tentacles; principally to show the prolongation of the chymiferous tube into the lappets of the oculiferous lobe, and the mode of formation and broadening of the radiating canals. 40 diameters.

Fig. 3. View from above of a portion of the tentaculate margin and the veil, from fig. 18, Pl. XIᵇ. Beside the general lettering we have *α* the outer and *β* the inner wall of i^2; *γ* the outer wall of i^1 where it passes into the outer wall (*ε*) of i^2; *δ* the inner wall of i^2 where it passes into the inner wall of i^3; *ε* the outer wall of i^2; *ζ* the inner wall of i^2 seen in the distance; *η* the inner wall of i^3 nearer to the eye

than ζ; θ the same as η, but still nearer to the eye; ι where η and θ merge into one outline; κ the cavity between the outer and inner walls of i^3; λ hollow of the tentacle; μ entrance to λ; o superior margin of the socket from which i^3 arises. 200 diameters.

Fig. 4. The same as fig. 3, but seen from below, with the following additional letters: ν the same as λ, but foreshortened by the curvature of the tentacle; ξ the inferior margin of the socket from which the tentacle arises; π the broad line of attachment of the veil (i). 200 diameters.

Fig. 5. Inferior side of a quarter of figs. 5 and 20 of Pl. XI[b]., principally to show the branching of the radiating canals, the extent of the veil, and the fringes (a) of the proboscis. 24 diameters.

Fig. 6. The fringes (a) of the proboscis of fig. 5 in profile.

Fig. 7. Cells (c) and lasso-cells (a b) from the upper surface of the disk of fig. 9. 500 diameters.

Fig. 8. The same as d^1 fig. 2, more enlarged. α entrance; β dorsal side toward the outer veil; γ profile of the wall at the dorsal side of the bend; δ profile of the lower side of the curve. 100 diameters.

Fig. 9. View similar to fig. 4, from the same ephyra as fig. 2. The letters as in fig. 4 excepting ε, which is the outer wall of a very young lobule developing between the larger ones; ρ cavity of the young lobule (ε); ς groups of lasso-cells. 100 diameters.

Fig. 10. Cellular tissue from the proboscis of an adult Aurelia, treated with alcohol. 500 diameters.

Fig. 11. The eye and the immediate organs, seen obliquely from the outer end. In addition to the general lettering, there is α the entrance to d^1; β the dorsal side of the external half of d^1; γ profile of the wall at the bend of d^1; ε ζ the wall of d^1. 200 diameters.

Fig. 12. The same as fig. 10, but in a natural state. 500 diameters.

Fig. 13. Similar to fig. 3, but from fig. 5. The figures 1 2 2a 3 refer to the tentacles, from the oldest to the youngest. Lettering as in fig. 2, with this difference, that ξ is seen through the tentacles; τ where the outer wall of the tentacles passes into that of its neighbor. 100 diameters.

Fig. 14. Profile sectional view of the walls of the hydra stem of Coryne mirabilis. a the horn-like sheath; b cells of the outer wall; b^1 mesoblast of b; c the same as b, seen in the distance; d cells of the inner wall; $d.d$ brown cells; e the same as d, in the distance. 500 diameters.

Fig. 15. A lasso-cell from the outer wall of fig. 14. a the cell wall; b the straight part of the thread; c d e the first, second, and third coils; f aperture of the cell and base of b. 2,000 diameters.

PLATE XII.

Pelagia cyanella, *Pér.* and *LeS.*

[Drawn from nature by J. Burckhardt.]

Fig. 1. Profile view, natural size.

Fig. 2. View from below, the mouth appendages being removed. a arms; b ovaries; c mouth; d tentacles; e eyes.

Fig. 3. View from above. a eyes; b chymiferous tubes; c digestive cavity; d tentacles.

Figs. 4 to 16. Planulæ and ephyra of the same.

Fig. 4. Young planula, seen in profile.

Fig. 5. Older planula, seen in profile.

Figs. 6 and 7. Older planula, seen from above, and in profile.

Figs. 8 and 9. Passage of the planula into the ephyra, in profile fig. 8, and from below fig. 9.

Figs. 10 and 11. Young ephyra, in profile and from below.

Fig. 12. Older ephyra, from below. c mouth; b eye-specks; a position of the tentacles at a more advanced period.

Fig. 13. Magnified spheromere in connection with the mouth. a chymiferous lobes; b eye; c mouth.

Figs. 14 and 15. Magnified eyes. a eye proper; b chymiferous tube of the eye.

Fig. 16. Magnified mouth, still simple and without arms.

PLATES XIII. and XIII[a].

Polyclonia frondosa, *Ag.*

[Drawn from nature by J. Burckhardt.]

Plate XIII. Profile view and various structural details of Polyclonia frondosa.

Fig. 1. Profile view of our Polyclonia (the Medusa frondosa of Pallas), with the oral appendages drawn up under the disk.

Fig. 2. The same, seen from below, different parts being removed in different segments and shown in a different condition in each. o o eyes, twelve in number. In segments 1 and 2 may be seen the two branches of one arm with their marginal lobes entire, and

covered with lasso-bearing papillæ at the base. In segments 4 and 5 another arm is visible with its marginal lobes and papillæ removed, in order to show that the arms have the same structure in the Discophoræ Rhizostomeæ as in the Semæostomeæ, only that their margin is soldered in the Rhizostomeæ, having only narrow openings for the admission of the food, instead of forming open channels. In segments 7 and 8 the base of the arm, with its papillæ *m*, is alone preserved. In segments 10 and 11, and parts of 9 and 12, the base of the oral appendages is removed to show the main cavity of the body *c c*. In segments 6[1] and 7 the ramifications of the chymiferous tubes are represented as they appear through the lower floor when injected. In segments 8, 9, 10, 11, and 12 different aspects of the lower surface of the lower floor are represented; in segments 11 and 12 from a specimen in which it was almost smooth; in segments 9 and 10, with various folds, concentric near the margin, convolute further inward, and pennate between the principal chymiferous tubes. In segment 8 the same arrangement prevails, but differently combined.

Fig. 3. Young specimen of Polyclonia frondosa seen from below. *o* eyes; *t* arms or oral appendages.

Fig. 4. Internal view of the main cavity with the four sexual pouches *o os oa*. *o* sexual organ suspended between the folds *os* of the sexual pouches; *oa* openings of the sexual pouches, alternating with the arms *t t*, t^1 t^1, t^2 t^2, t^3 t^3; *s* openings of the channels of the four arms into the main cavity.

Fig. 5. Central cavity seen from below, with a few chymiferous tubes radiating from one of its corners.

Figs. 6 and 7. Openings of the channels leading into the main cavity.

Figs. 8, 9, 10, 11, 12, 13, and 14. Various kinds of lasso-bearing papillæ, *l*, from the base of the arms.

Figs. 15 and 16. Lobes of the margin of the arms with their fringes *t*, to show the openings *s*, leading into the main channel of the oral appendages.

Fig. 17. Lasso-cells.

PLATE XIII[a]. Side view of Polyclonia frondosa, with various structural details.

Fig. 1. Profile view of Polyclonia, with the disk somewhat raised in front to show the opening of a sexual pouch between two arms.

Fig. 2. Transverse section of the disk.

Fig. 3. Portion of the same, magnified. *g* upper floor; a^2 layer of the chymiferous tubes; *o* lower floor.

Fig. 4. Portion of an arm, seen from its outer side, with the marginal lobes and fringes extended.

Fig. 5. The same, from the inner side. *s* channels leading into the main cavity; *d* marginal lobes and fringes; d^1 papillæ of the base of the arm.

Fig. 6. View of the disk from above.

Fig. 7. Segment of the same, in which the colored ring is not divided into several zones as in fig. 6.

Fig. 8. Portion of the margin, with two eyes, o^1 o^1, in the same spheromere.

Fig. 9. Magnified portion of the margin, showing the anastomoses of the chymiferous tubes a^2.

Figs. 10, 11, and 12. Margin of the disk, to show how the edge is thinned out into a sort of veil, beyond the marginal lobules, between which the eyes, *o* (figs. 11 and 12), are situated.

Figs. 13, 14, and 15. Eyes.

Figs. 16, 17, 18, 19, 20, 21, and 22. Eggs in various stages of development.

Fig. 23. Spermatic particles.

PLATE XIV.

STOMOLOPHUS MELEAGRIS, *Ag.*

[Drawn from nature by A. Sonrel and J. Burckhardt.]

Fig. 1. Profile view of Stomolophus Meleagris.

Fig. 2. Profile view of the oral appendages, presenting two rows of prominent crests, the upper of which is concealed under the disk in their natural position.

Fig. 3. Transverse section across the upper part of the oral appendages, just below the main cavity.

Fig. 4. View of the oral appendages from below. The letters and figures in figs. 2, 3, and 4 correspond to one another.

Fig. 5. One of the crests of the upper row seen sideways.

Fig. 6. The same, its two halves being separated.

Fig. 7. One of the crests of the lower row seen sideways.

Fig. 8. The end of the same seen from above.

PLATE XV.

PENNARIA GIBBOSA *Ag.*, MILLEPORA ALCICORNIS *Linn.*, POCILLOPORA DAMICORNIS *Lmk.*, SERIATOPORA SUBULATA *Lmk.*

[Figs. 1, 1a, 2, 9, 10, 11, 12, 13, 14, 14a, 15, and 15a drawn from nature by A. Sonrel; figs. 4, 5, 5a, 5b, 5c, 6, 7, and 8 by H. J. Clark, from sketches by L. Agassiz and the help of alcoholic specimens; fig. 3 by J. Burckhardt.]

Millepora, Pocillopora, and Seriatopora were thus far referred to the Polyps.

Figs. 1, 1a, and 2. Pennaria gibbosa.

Fig. 1. A broadside view of a stem, natural size. *a* the stem; *b* the large terminal hydræ of the branches (*c*); *d* the large terminal hydra of the stem.

Fig. 1a. View at right angles to fig. 1, to show the curve of the stem and branches.

Fig. 2. A portion of the stem, bearing a branch. A the main stem; A¹ rings of A; B the large terminal hydra of the branch; C the youngest hydra, a mere bud as yet; D E F G hydræ, lettered according to their ages; *a* basal rings of the branch; *a*¹ rings along the branch; *a*² terminal rings of the branch; *a*³ pedicel of C; *a*⁴ end of the pedicel of D; *b* pedicel of the large medusa (*d*⁵) of G; *d* the medusa of D; *d*¹ medusa of E; *d*² *d*³ medusæ of F; *d*⁴ *d*⁵ medusæ of G; *e* *e*¹ the sexual organs of the medusa (*d*⁵); *e*² circular canal of *d*⁵; *f* the proboscis of *d*⁵; *g* the tentacles of *d*⁵; *h* the radiating canals of *d*⁵; *m* mouth of the hydra; *p* proboscis of the hydra; *p*¹ the bulging side of *p*; *p*² the proboscis of F, stretched out; *t* *t*¹ the crown of tapering tentacles; *t*² *t*³ the globe-tipped tentacles of the proboscis. 15 diameters.

Figs. 3 to 13. Millepora alcicornis.

Fig. 3. A branch, natural size, covered by the extruded hydræ.

Fig. 4. A portion of fig. 3, magnified. *a* the outer wall in profile; *b* the surface of the branch; *c g h* the larger forms of hydræ, with only four to six tentacles; *i k l m n* the smaller hydræ, with numerous tentacles; *d* the mouth of *c*, shown by the bending of the head to one side; *e* the aperture of the cell of *c*; *f* aperture of the cell of *g*; *p* aperture of the cell of a small hydra. 25 diameters.

Fig. 5. One of the smaller hydræ of fig. 4. *a* the outer and *b* the inner wall; *c* *c*¹ digestive cavity; *d* mouth; *e f g h i k l m* the short, globe-tipped tentacles; *n* the groups of brown cells (fig. 5c) in the inner wall. 100 diameters.

Fig. 5a. A lasso-cell from the tentacles. *a* the empty cell; *b* the base of the thread (*d e f*); *c* the thickened portion. 500 diameters.

Fig. 5b. A B C D E F other forms of lasso-cells. *a* the cell; *b* the base of the thread (in A the barbs); *c* the thread.

Fig. 5c. *a b c* brown cells from the inner wall. 500 diameters.

Fig. 6. One of the larger hydræ of fig. 4, with four tentacles. Letters as in fig. 5 excepting *h*, the stem of the tentacle. 100 diameters.

Fig. 7. Sectional view of fig. 6, to show the form of the cells of the inner wall. Letters as in fig. 5. 100 diameters.

Fig. 8. A portion of the surface of a branch, to show the form of the cells. *a* aperture of a cell of a large hydra; *b* cell of a small hydra; *c* the soft walls of the hydro-medusarium through which the calcareous, spongiform coral shines; *d* the spongiform body of the coral denuded; *e f* views into the cells of the large hydræ; *g* *g*¹ cells of small hydræ; *h i j k* irregular radiating partitions of the cells of small hydræ; *l m* radiating partitions of a large cell (*e*). 100 diameters.

Fig. 9. Longitudinal section of the cell of a large hydra with three transverse partitions, taken at a point one half of an inch below the tip of the branch. *a* the mouth of the cell; *b* the bottom of the cell; *c* transverse partitions; *d* irregular projections from the bottom of the cell; *e* apertures in the side of the cell, leading off into the spongiform mass; *f* branching cavities in the coral; *g h* sections of cavities like *e*. 100 diameters.

Fig. 10. Longitudinal section of a young, large hydra, taken at a point half an inch below the tip of a young branch. *a* mouth of the cell; *b* bottom of the cell; *c* sides of the cell; *d e f* radiating partitions; *g* section of an aperture like *h*; *i j* branching cavities in the coral; *k* solid part of the coral. 100 diameters.

Fig. 11. Transverse section of a branch one inch below its top. *a* highly spongiform axis; *b* mouth and *c* bottom of the cell; *d* *e*¹ *k* transverse partitions; *e f g h i* cells more or less exposed; *l* surface of the branch. 40 diameters.

Fig. 12. Transverse section one eighth of an inch below the top of a branch. *a* the spongiform axis; *b d e f* cells in various stages of development; *c g* bottom of the cells. 40 diameters.

Fig. 13. Longitudinal section of a large cell, from a stem half an inch in diameter. *a* mouth and *b* bottom of the cell; *c* the numerous transverse partitions; *d* the upper part of the cell only partially laid open. 40 diameters.

Fig. 14, 14a, 14b. Pocillopora damicornis.

Fig. 14. The tip of a young branch. *a* the youngest, and *b c d e f g* successively older cells. 40 diameters.

Fig. 14a. Transverse section of two young cells, *a b*, from fig. 14; *d* and *e* the bottom of the cells; *c* *c*¹ ridges between the cells.

Fig. 14b. Longitudinal section of an old branch. *a b* *c d e h i k* cells laid open, and exposing their numerous transverse partitions; *f g* mouths of cells not opened by the section; *j* transverse partition of *k*; *l* common bottom of *i* and *k*; *m* bottom of *h* and *c*, and perhaps of others. 5 diameters.

Fig. 15, 15ª. Seriatopora subulata.

Fig. 15. Tip of a branch. *a b c d e f g h i* the cells; *f* and *i* the quadruple aperture of the cell; *k* the projection of the central column, from which four partitions radiate to the walls of the cell. 40 diameters.

Fig. 15ª. Longitudinal section of a cell of fig. 15, one inch from the top of the branch. *a* mouth and *b* bottom of the cell; *c* axial column; *d e* the four cavities around the column; *f g* transverse partition; *h i* solid part of the coral; *j* bottom of the uppermost cell. 40 diameters.

TABLE XVI.

Hydractinia polyclina *Ag.*

[Figs. 1, 1a, 1b, 1c, 1d, 1e, 2, 2a, 2b, 2c, 2e, 4a, 4b, are drawn from nature by A. Sonrel; the others by H. J. Clark.]

Fig. 1. A female hydromedusarium. A B C F fertile individuals; D E G H I sterile individuals; K basal or stolonic layer; *e* medusa; *h* head of fertile individuals; *p* proboscis; *s* spiny, horn-like processes from the base. 25 diameters.

Figs. 1ª, 1ᵇ, 1ᶜ, 1ᵈ, 1ᵉ, different attitudes of the proboscis and tentacles which the sterile heads assume. *m* the mouth or actinostome; *t* the tentacles. 100 diameters.

Fig. 1f. Profile of a sterile female strongly contracted. *m* mouth; *t* tentacles. 60 diameters.

Fig. 1g. A fertile female hydra without any medusæ. *t* tentacles. 100 diameters.

Fig. 2. A male hydromedusarium. A B C K the fertile individuals; D E F G H I sterile individuals; letters as in fig. 1. 25 diameters.

Fig. 2ª. A fertile male with the proboscis expanded and the mouth (*m*) wide open. *t* the globular tentacles. 100 diameters.

Fig. 2ᵇ. The same as fig. 2ª with the mouth (*m*) shut.

Fig. 2ᶜ. A sterile male strongly contracted, so that the tops of the tentacles are globular, and in two rows (t t^1). 100 diameters.

Fig. 2ᵈ. The tentacles more strongly contracted than in fig. 2ᶜ; the proboscis reverted and the mouth wide open. 125 diameters.

Fig. 2ᵉ. The same as fig. 2ᵇ, but the proboscis (*p*) more enlarged.

Fig. 2f. A globular tentacle of a fertile male. *a* outer and *b* inner wall; *d* prolongation of the digestive cavity. 500 diameters.

Fig. 2g. A sterile male strongly contracted. *p* proboscis; *t* tentacles. 60 diameters.

Fig. 2h. The proboscis of a sterile male. *a* outer and *b* inner wall; *d* digestive cavity; *m* mouth. 300 diameters.

Fig. 3. A fertile female crowded with medusæ. *a* outer and *b* inner wall; a^1 outer and b^1 inner wall of the medusa; *c* peduncle of the medusa; *d* digestive cavity; d^1 digestive cavity of the proboscis of the medusa; *e* eggs; *p* proboscis of the medusa; *t* tentacles; A a medusa foreshortened. 300 diameters.

Fig. 3ª. View from the actinal end of a medusa of fig. 3. a^1 outer and b^1 inner wall; *v* yolk sac; *y* yolk; *p* Purkinjean vesicle; *w* Wagnerian vesicle; *vl* Valentinian vesicle; A one of the eggs in a superficial view. 500 diameters.

Fig. 4. A fertile male crowded with medusæ, which are discharging their spermatic particles. *a* partially empty and *b* entirely empty medusæ; *h* the head. 125 diameters.

Fig. 4ª. Actinal end of a fertile male hydra. *a* to *i* different stages of development of the medusæ; *m* the open mouth. 100 diameters.

Fig. 4ᵇ. Similar to fig. 4ª, but younger. *h* the head.

Fig. 5. A young sterile male and a portion of the retiform stolon. *a* outer wall of the stolon; a^1 outer wall of the hydra; *b* network formed by the interior wall; *c* digestive cavity; *d* inner wall; *e* and *f* horn-like spines; *p* proboscis; *t* tentacles. 300 diams.

Fig. 5ª. A portion of the edge of a stolonic base to show a budding of a new channel (*f*); *c* outer wall; *a b* line of the section from which fig. 5ᶜ was taken; *d* cells of the outer wall; *e* chymiferous canal; *f* young canal budding; *g* granular contents of *e*. 400 diameters.

Fig. 5ᵇ. A very young male hydra budding from the base. *a* outer and *b* inner wall of the stolon; a^1 outer and b^1 inner wall of the hydra; *c* digestive cavity. 400 diameters.

Fig. 5ᶜ. A section through *a b*, fig. 5ª. *a* a^1 outer wall; *b* cells in *a* a^1; *c* chymiferous canal of the inner wall (*d*).

Fig. 6. One of the horn-like spines of fig. 5, to show that it is covered by the retiform stolon. *a* interstices of the net-work: *b* b^1 the canals; *c* the spinules of the spine; *d* outer wall. 300 diameters.

Fig. 7. A very young male medusa bud. *a* outer

and *b* inner wall of the hydra; *d* digestive cavity; *l* lasso-cells. 400 diameters.

Fig. 8. A two-thirds grown medusa. *a b d l* as in fig. 7; *b'* inner wall of the medusa; *b'* point of transition of *b'* into the wall of the proboscis *c*; *e* cavity of the disk, containing the spermatic mass. 400 diameters.

Fig. 9. A ripe medusa. *a* outer *b* inner wall of the peduncle; *b'* as in fig. 8; *c* proboscis; *d* digestive cavity; *e* the spermatic mass.

Fig. 9a. Spermatic particles from fig. 9; A is magnified 500 diameters; B an exaggerated figure to show the form of A; *h* the so-called head; *t* the filament.

Fig. 10. Lasso-cells from the medusæ of fig. 4. 500 diameters.

Fig. 11. Lasso-cells from fig. 2f. *a* a closed cell; *b* a cell with the thread (*c*) out; *b'* the base of *c*. 800 diameters.

Plates XVII., XVIII., and XIX. represent the structure and growth of one of the most common Hydroids of the Bay of Boston, and the mode of growth and structure of its medusa, which I have already described in my first paper on the Acalephs of North America, under the name of Sarsia mirabilis.

PLATE XVII.

Coryne mirabilis *Ag.*

[Figs. 1, 1a, 3, 4, 5, 6, 7, 8, 9, 10, and 11a drawn by A. Sonrel; the others by H. J. Clark.]

Unless when stated otherwise, the following letters refer to the same parts in all the figures. *a* inner wall of the hydra; *b* outer wall; *c* horn-like sheath; *cn* top of the stem; *d d'* digestive cavity of the stem and head of the hydra; *dc* disk of the medusa; *m* mouth of the hydra; *md* medusa buds; *n* proboscis; *p* peduncle of the medusa; *pr* transverse veil of the medusa; *r* tentacles of the medusa; *s* stem of the hydra; *t* tentacles of the hydra.

Fig. 1. A group of hydræ attached to a sea-weed. It being the beginning of the breeding season (January 31, 1855), the young medusa buds are not conspicuous. Natural size.

Fig. 1a. A portion of fig. 1 magnified about 20 diameters. *a* a very young hydra bud.

Fig. 2. A single individual, showing that the medusæ are sometimes developed among the tentacles (see *md*). *m* other medusæ below the tentacles. 40 diameters.

Figs. 3 to 8. Show the various ages and attitudes of the hydra. *a a'* medusæ buds in different stages of growth. 40 diameters.

Fig. 9. A head of a hydra, contracted, showing the horn-like sheath (*c*) separated from the neck. 100 diameters.

Fig. 10. A group of hydro-medusæ late in the breeding season (April 25, 1855), when the heads are resorbing and the medusæ are prominent. (See figs. 11, 12, 13, 14, and 15.) Natural size.

Fig. 11. A male hydra from fig. 10, the medusa persistent, and developing the spermatic mass around the proboscis (*n*) to an enormous extent. 60 diameters.

Fig. 11a. View of fig. 11 from the actinal end.

Fig. 12. A male hydra from fig. 10; the almost perfect medusa is persistent and withering, having discharged its spermatic contents. *d* peduncle of the medusa. 40 diameters.

Fig. 13. Similar to fig. 12, but the tentacles of the hydra have begun to be resorbed. The medusa is proportionately larger, and has no tentacles. 40 diameters.

Fig. 14. The head of the hydra is nearly all resorbed, and the medusa, without tentacles, is withering, having discharged its spermatic particles. 40 diameters.

Fig. 15. The head of the hydra, a female, is altogether resorbed, and the medusa terminates the stem, like a head. *a'* the radiating canals, of which there are five. 60 diameters.

Fig. 16. A female medusa attached to a hydra, and the proboscis enormously distended and crowded with eggs. 40 diameters.

PLATE XVIII.

Coryne mirabilis *Ag.*

[All the figures are drawn from nature by H. J. Clark.]

Figs. 1 to 12 are magnified 400 diameters.

Fig. 1. A medusa just beginning to bud. *a* inner and *b* outer wall of hydra; *c* inner and *b* outer wall of the bud.

Fig. 2. The medusa bud already semi-globular. *a* outer and *b* inner wall of the hydra; *c* inner and *d* outer wall of the medusa; *e e'* chymiferous cavity leading into the medusa.

Fig. 3. Little older than fig. 2, and stretched longitudinally. Letters the same as in the last.

Fig. 4. The radiating tubes beginning to develop.

Fig. D.

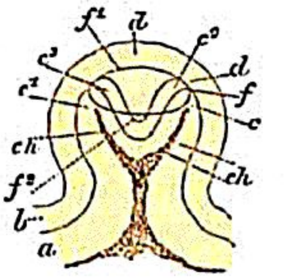


Fig. D represents fig. 4 in outline. *a* inner and *b* outer wall of the hydra. — $c\ c^1\ c^2\ c^3$ the four radiating tubes. — *ch* channel of *c*. — *d* outer wall of the medusa. $f\ f^1\ f^2$ edge of the inner wall in which $c\ c^3$ are hollowed.

Fig. 5. A little further advanced than fig. 4.

Fig. E.

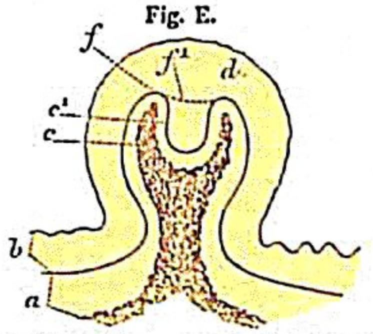


Fig. E represents fig. 5 in outline. *a* inner and *b* outer wall of the hydra. — *c* outer and *c* inner sides of the radiating canal. — $f\ f^1$ edge of the inner wall. — *d* outer wall.

Fig. 6. A little older than fig. 5.

Fig. F.

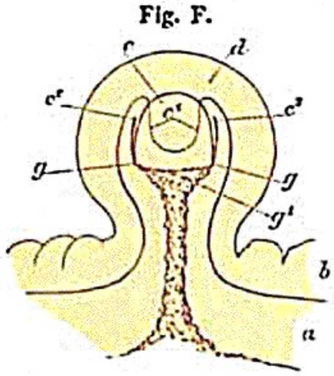


Fig. F represents fig. 6 in outline. *a* inner and *b* outer wall of the hydra. — *c* a broad radiating tube seen from its outer face. — c^1 inner and c^2 outer face of the radiating tubes, in profile. — *d* outer wall. — $g\ g^1$ base of the radiating tubes.

Fig. 7. Sectional view of fig. 6, to show the projection (d^1) of the outer wall into the cup-like hollow of the inner wall (*c*). *a* inner and *b* outer wall of the hydra. As this figure was drawn for the purpose only of showing how the outer wall projects into the hollow of the inner wall, no special references are needed to the other parts, which, by comparison with fig. 6, explain themselves.

Fig. 8. Considerably older than figs. 6 and 7, showing the prolongation of the horn-like sheath over the disc, and the broad radiating tubes.

Fig. G.

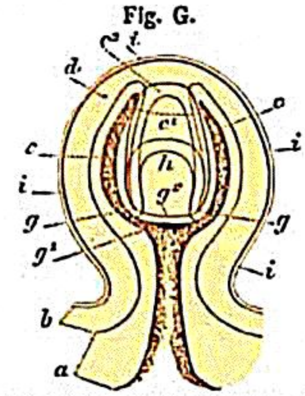


Fig. G represents fig. 8 in outline. In the plate the proboscis (*h*) is omitted. *a* inner and *b* outer wall of the hydra. — *c* outer and c^1 inner face of the radiating tubes, in profile. — c^2 a broad tube next the eye. — *d* outer wall of the disc. — *g* base of the radiating tubes and the proboscis (*h*) in profile. — $g^1\ g^2$ outlines of the wall where the proboscis and the tubes meet. — *i* horn-like sheath.

Fig. 8a. View of the actinal end of fig. 8.

Fig. H.

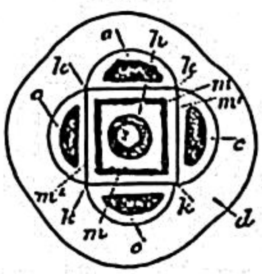


Fig. H represents fig. 8a in outline. *c* the radiating tubes. — *d* the outer wall. — *k* edges of *c*. — *m* inner and m^1 outer surface of the innermost wall. — *h* the proboscis.

Fig. 9. A little older than fig. 8, showing the lateral projection of the radiating tubes preparatory to the formation of the circular tube. $a\ a^1$ inner wall of the radiating tube; $b\ b^1$ outer wall of the disk; b^1 outer wall of radiating tube near the edge of the disk; *c* the same as b^1, but near the abactinal end; *l* the lateral projections from the radiating tubes; *n* the proboscis.

Fig. I.

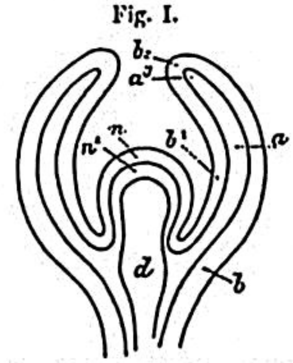


Fig. I represents a sectional view of fig. 9 at a point between the radiating canals. — *a* the middle wall. — a^2 edge of *a*. — *b* outer wall, continuous at b^2 with the innermost wall (b^1). — *d* digestive cavity. — *n* outer wall of the proboscis, continuous with b^1. — n^1 inner wall of the proboscis continuous with *a*.

Fig. 10. The radiating tubes about uniting laterally to form the circular tube. The horn-like sheath is very conspicuous.

Fig. K.

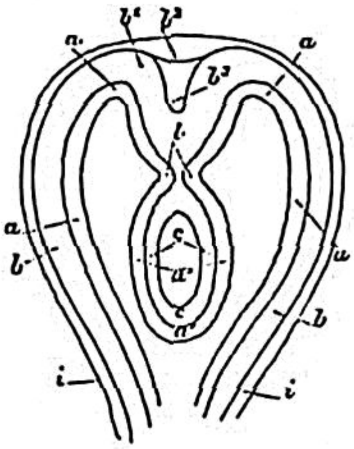


Fig. K represents fig. 10 in outline. a a^1 middle wall of the disk, in which the radiating tubes are hollowed.—b outer wall.—b^1 outer wall inverted.—b^2 edge of the inversion b^1.—b^3 bottom of the hollow formed by the inversion of b^1.—c innermost wall, thrown into profile by the projection of the radiating tubes.—i horn-like sheath.—l diverticuli from the radiating tubes to form the circular tube.

Fig. 11. The circular tube is just formed by the lateral junction of the radiating tubes. The tentacles begin to be prominent.

Fig. L.

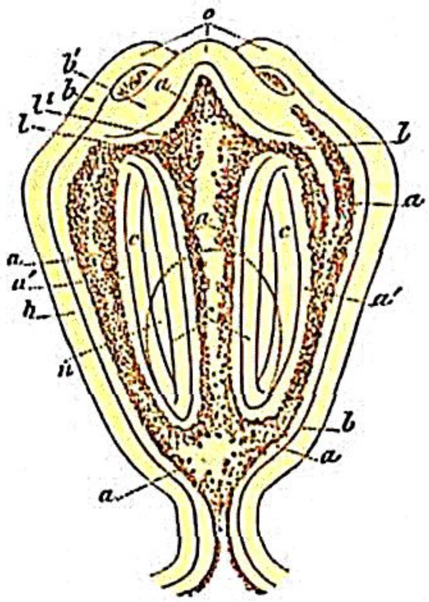


Fig. L represents fig. 11 in outline. a a^1 the middle wall, in which the radiating tubes are hollowed.—a^1 in profile in the plane of the axis.—b outer wall of the disk.—b^1 outer wall at the point of involution.—c c^1 innermost wall.—l circular canal.—l^1 junction of the radiating and circular canals.—n the proboscis.—o the incipient tentacles.

Fig. 12. The circular tube is complete, the transverse veil is distinctly three walled, and the proboscis is quite large, but it occupies still a comparatively larger part of the cavity of the body than afterwards, and is globular.

Fig. M.

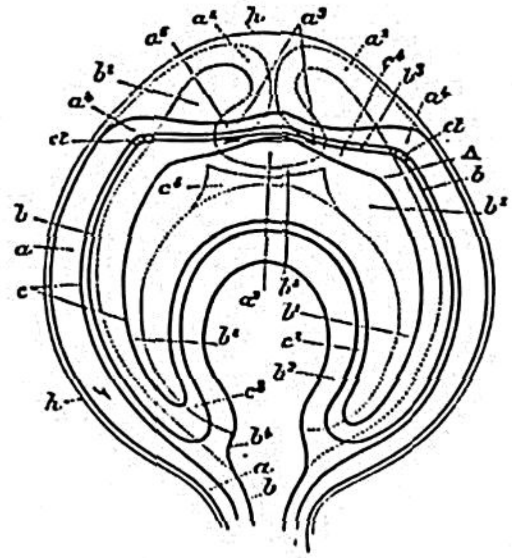


Fig. M represents fig. 12 in outline. This figure is a combination of a profile and a surface view, the radiating tubes being nearest to the eye. a outer wall of the disk or pedicel.—a^1 outer wall of the tentacles.—a^2 continuation of a and a^1 along the edge of the disk.—a^3 where a^1 and a^2 meet.—a^4 corresponds to a^3, in profile.—a^5 outer wall of the veil, here seen in profile, in the distance.—A the point of the innermost wall, in profile, which corresponds to c^5.—b the middle wall of the disk, or inner wall of the pedicel.—b^1 the same as b but nearer the eye, and hollowed out by the radiating canal.—b^2 inner wall of the proboscis continuous at b^3 with b.—b^3 the middle wall of the veil, continuous with b.—b^4 origin of the radiating canals b^1.—b^5 circular canal.—c the outer and inner outlines of the innermost wall.—c^1 the outer wall of the proboscis at c^3 continuous with c.—c^4 the innermost wall of the veil in profile.—c^5 the same as c^4 but nearer the eye.—cl the circular tube cut across in b.—h the horn-like sheath, which completely incloses the medusa.

Fig. 13. Shows the tentacles (a) before they are curled into the cavity of the disk.

Fig. 14. The tentacles highly developed, and curled inwardly, forcing the transverse veil into the cavity of the disk.

Fig. N.

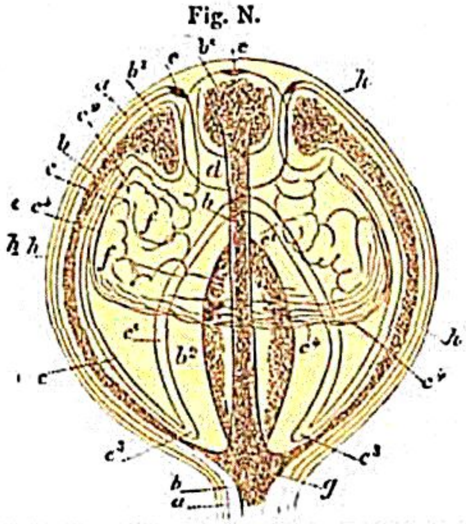


Fig. N represents fig. 14 in outline. Although the tentacles are curled inwardly, they are shut off from the cavity of the disk by the veil (c^2 c^4). a the outer wall.—b the inner wall of the pedicel, or middle wall of the disk, and containing the radiating canals.—b^1 the bulbous cavity of the tentacles.—b^2 inner wall of the proboscis, continuous with b.—c the innermost wall.—c^1 outer wall of the proboscis, continuous with c.—c^2 periphery of the veil (c^4).—c^3 point of union of c and c^1.—c^4 the veil.—d the tentacular bulb.—e the eye-speck.—f the tentacles.—g the future digestive cavity.—h the horn-like sheath.

Fig. 15. A medusa just dropped from the hydra. Feb. 14, 1855. Natural size.

Fig. 15ᵃ. The same as fig. 15, magnified about 40 diameters. *a* remains of the chymiferous channel of the peduncular attachment; *b* outer wall of the proboscis; *c* radiating tubes; *c*¹ circular tube; *d* fold of the innermost wall; *d*¹ trausverse fold of the inner wall; *e* aperture of the proboscis.

Fig. 16. A young free medusa, in a dying state, compressed and folded longitudinally. Seen from the abactinal end. *a* innermost wall receding from the disk (*b*); *c* radiating tubes; *d* digestive cavity. 100 diameters.

Fig. 17. View from the abactinal end of a medusa a little older than fig. 15ᵃ. *a* the veil; *b* circular tube; *c* proboscis; *d* digestive cavity; *e* innermost wall; *e*¹ point of attachment of *e* to the disk. 100 diams.

Fig. 18. About the same age as fig. 17, but very much contracted. *a* longitudinal folds; *b c* corrugated lines on the outer surface of the disk. 125 diameters.

Figs. 19, 20, 21, 22, 23, and 24 are all lettered alike. *v* the vitelline sac; *y* yolk; *p* Purkinjean vesicle; *w* Wagnerian vesicle; *vl* Valentinian vesicle.

Figs. 19, 20, 22, 23, and 24. Various stages of development of the eggs of a full-grown free medusa. May 17, 1855. 500 diameters.

Fig. 21. An egg from fig. 15, Pl. XVII. 500 diameters.

Fig. 21a. A layer of eggs from fig. 15, Pl. XVII. *a* outer and *b* inner wall of the proboscis. 400 diameters.

Figs. 25 and 25ᵃ. Spermatic particle of a full-grown free medusa. Fig. 25, 500 diameters; fig. 25ᵃ exaggerated, the better to show the form.

PLATE XIX.

Coryne mirabilis *Ag.*

[All the figures are drawn from nature by H. J. Clark.]

Fig. 1. A portion of the body and a tentacle of a hydra, showing the furrows *g g*¹ in the outer wall *b b*¹. *f* globular mass of lasso-cells. 500 diameters.

Fig. 2. Portion of the body and a sectional view of a partially extended tentacle. *a* outer wall of the body in profile; *a*¹ the same as *a*, in a full view; *a*² *a*³ *a*⁴ cells of the inner wall of the tentacle; *b* outer wall of the body; *b*¹ outer wall of the tentacle; *c* horn-like sheath; *d* outline of the digestive cavity; *e* space between the outer and inner walls of the tentacle; *f* layer of lasso-cells at the tip of the tentacle; *g* processes around the mesoblast of the cells of the tentacle. 400 diameters.

Fig. 3. Surface view of a tentacle. *a b* cells of the inner wall; *c* outer wall; *d e g* profile of cell walls of *a b*; *f* globular mass of tentacles. 300 diameters.

Fig. 4. Sectional view of the body just below the tentacles. *a* inner wall; *b* outer wall; *c* horn-like sheath; *d* digestive cavity. 500 diameters.

Fig. 5. Lasso-cell of a hydra. *a* wall of the cell; *b* *b*¹ *b*² axial column, which corresponds to the base of the lasso-thread; *c* the anchors; *d* coil of the lasso; *f* aperture. 1100 diameters.

Fig. 5ᵃ. The same as fig. 5 uncoiled. *a* the empty cell; *b* thicker part of the base of the lasso-thread; *b*¹ where the thread begins to taper; *c c*¹ the anchors or barbs. *c*¹ is seen through *b*; *d* the thread; *d*¹ end of the basal portion; *e* cavity of *a*; *f* aperture of the cell.

Fig. 6. Lasso-cell from the proboscis of a full-grown free medusa. *a* profile of the spiral coil *d*; *f* aperture of the cell. 1100 diameters.

Fig. 6ᵃ. The same as fig. 6, but the basal portion of the thread everted. *a* the inverted thread passing through the basal part back to the coiled part *d*.

Fig. 7. Edge of the disk and a tentacle of fig. 13, Pl. XVIII., principally to show the cellular structure of the outer wall (*a*¹) of the tentacle, and disk (*a*); *b* wall of the radiating tube; *b*¹ inner wall of the tentacle, continuous with *b*; *c* circular canal; *d* cavity at the base of the tentacle; *d*¹ channel of the tentacle; *e* innermost wall of the disk. 400 diameters.

Fig. 7ᵃ. The outer wall of the disk of fig. 7 in profile, and more highly magnified. *a* outer ends; *b* inner ends. 500 diameters.

Fig. 7ᵇ. Superficial or end view of fig. 7ᵃ.

Fig. 8. Eye-speck of fig. 15ᵃ, Pl. XVIII. *u* outer wall, and *v* inner wall, of the exterior base of the tentacle; *w* a lasso-cell. 1100 diameters.

Fig. 8ᵃ. A few oily globules from the dark mass of fig. 8.

Fig. 9. The edge of the disk and the base of a tentacle of the medusa of fig. 12, Pl. XVII. *a* outer wall of the tentacle; *b* circular tube; *d* entrance of *b* into the radiating tube (*c*); *e* innermost wall of the disk. 200 diameters.

Fig. 10. Profile section of a part of the disk and radiating tube of a medusa about ready to drop from the hydra. *a* wall of the tube; *b* innermost wall, and *b*¹ middle wall, of the disk; *c* outermost wall. 500 diameters.

Fig. 11. About the same age as fig. 10, showing the radiating tube *a* a^1 a^2 to be distinct from either the outer (*c*) or the innermost wall (*b*); *d* striæ of *b*. 500 diameters.

Fig. 12. Part of the disk of a medusa only a day or two old; after being in alcohol; *a* dotted striæ of the innermost wall; a^1 the same as *a* in profile; *b* blister-like projections of the cells of the same wall; b^1 the same as *b*, in profile; *c* outer surface of the disc. 500 diams.

Fig. 13. Inner face of the disk and radiating tube of a medusa just set free. *a* cells of the innermost wall; *b* the same as *c*, covering the tube (*c*). 500 diams.

Fig. 14. From a medusa ready to drop from the hydra; the edge of the disk was involuted so as to bring its thickness into sharp profile; *a* outer wall; a^1 cells of *a*; *b* middle wall, continuous with the inner wall of the hydra, and the same as the inner wall of the very young medusa; b^1 thickening of *b* where it embraces the radiating canal d^1, which is hollowed out in it; *c* innermost wall; c^1 the papillate cells in profile; c^2 the same as *c* in the distance; *d* radiating canal passing into the distance; d^1 the same as *d* in transverse section; *e* the horn-like sheath. 400 diameters.

Fig. 14ª. Cells from the outer wall of a medusa of the same age as fig. 14. *a* the cell wall or ectoblast; *b* the mesoblast; *c* the entoblast. 500 diameters.

Fig. 14ᵇ. Cells of the innermost wall of the same medusa as those of fig. 14ª. 500 diameters.

Fig. 15. The proboscis of a medusa two or three days old. Superficial and profile views combined in one figure, as one may see it merely by changing the focus; *e* radiating tubes nearest the eye; e^1 the same as *e* where they open into the digestive cavity; *g* outer wall of the proboscis, which at g^1 becomes the innermost wall of the disk; *h* the large wedge-shaped cells of the inner wall, in profile; h^1 the same as *h* in a superficial view; h^2 the same as *h* and h^1 where it becomes the middle wall of the disk; and h^3 where it becomes the wall of the radiating tube (*e*); h^4 the remains of the same wall when it has formed the inner wall of the peduncle; h^5 where *h* diverges to form a broad space for the digestive cavity of the disk; *i* cavity of the proboscis; *k* lasso-cells; *m* to m^1 longitudinal furrows upon the outer wall of the proboscis; *n* the outer wall of the disk dragged inward by the retraction of the adherent inner or middle wall (h^2); *o* o^1 parietes of the outermost wall of the disk around the depression formed by the inflection of *n*. 500 diameters.

Fig. 16. Base of the proboscis and the neighboring centre of the disk of a medusa a little younger than fig. 15, and with the same lettering; beside which e^2 is the wall of *e*; i^1 digestive cavity of the disk. 400 diameters.

Fig. 17. Edge of the disk and the base of a tentacle of a medusa about as old as fig. 16. *a* parietes of the disk; a^2 a^3 outer wall of the tentacle; *b* the thick irregular wall of the radiating tube; b^1 the circular tube; b^2 the junction of *b* and b^1, or the bulb cavity; b^3 inner wall of the tentacle continuous with *b* b^1; *c* c^1 innermost wall of the disk; *d* the eye-speck. 400 diameters.

Fig. 18. Exterior face view of the base of a tentacle and its bulb cavity; from a medusa three days old. *a* eye-speck; *b* inner wall of the bulb, or point of junction of the radiating (*c*) and circular (*d*) canals; *e* outer wall of the bulb; *f* projection of the disk over the base of the tentacle; *g* outer wall of the tentacle; *h* inner wall of the tentacle; *i* cavity of the tentacle; *k* lasso-cells; *l* bulb cavity. 400 diams.

Fig. 19. The same as fig. 18, seen from above, with the same letters; showing the truncate cone (*a*) of the eye-speck. 500 diameters.

Fig. 20. View from above of the digestive cavity of the disk of a medusa three days old. *a* the digestive cavity; *b* radiating tubes; *c* wall of *b*; c^1 where the wall of *b* passes into the inner wall of the proboscis (*d*); c^2 innermost wall of the disk; c^3 the thick inner wall at the base of the proboscis, continuous with *c*, but seen in the distance. 500 diameters.

Fig. 21. Cells from the outer surface of the disk and veil of a medusa probably two or three days old; they are slightly swollen by fresh water. 500 diams.

Fig. 22. The same as fig. 21, in a natural state. *a* the mesoblast; *b* the entoblast. 500 diameters.

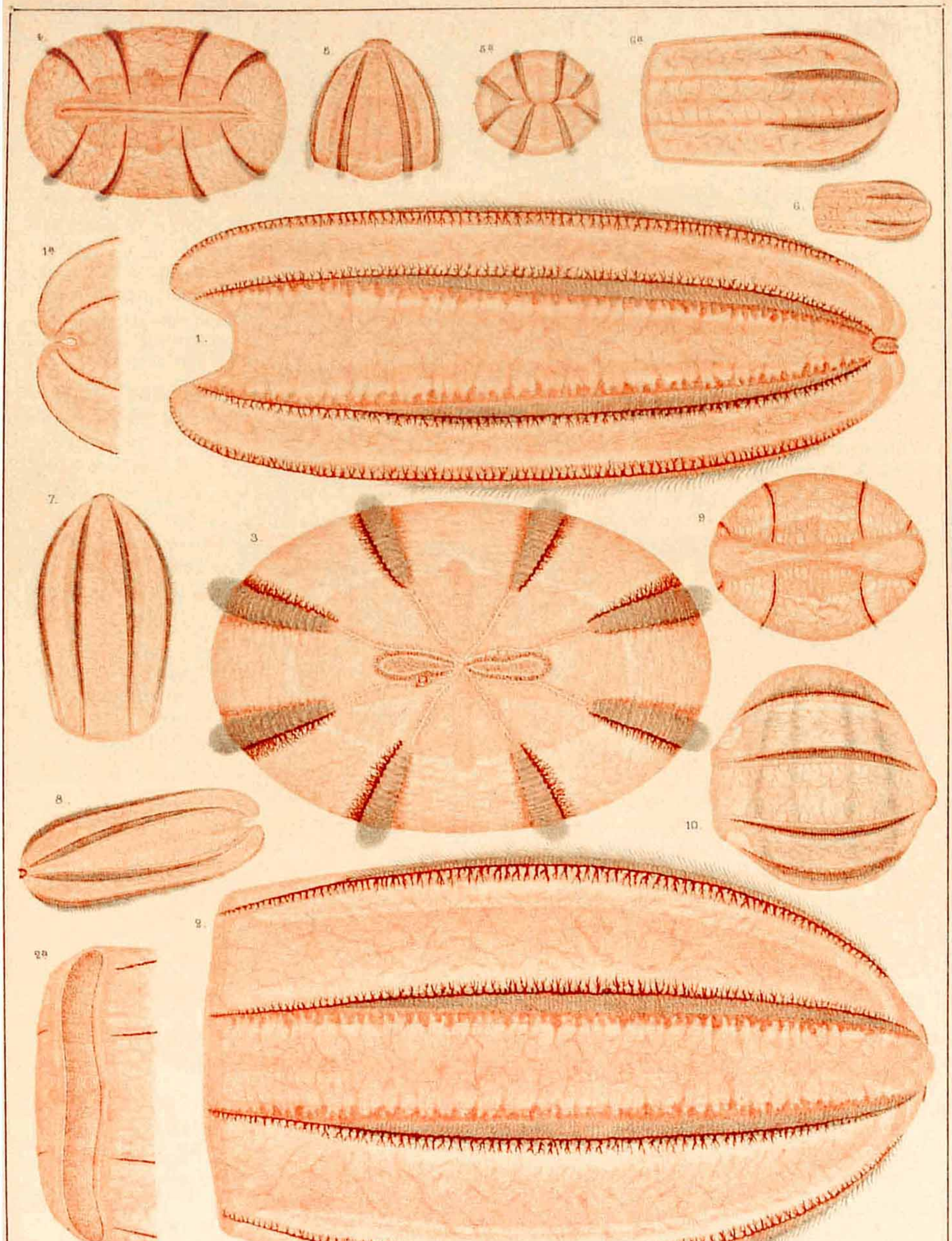
Fig. 23. The same as figs. 21 and 22. Cells of the innermost wall of the veil seen from the outside and through the concentric striæ of the middle wall. They are a little changed by alcohol. 500 diameters.

Fig. 24. Cells of the innermost wall of the disc, through which are seen the horizontal striæ of the middle wall. *a* the mesoblast. 500 diameters.

Fig. 25. Lasso-cells upon the tentacular bulb of a full-grown free medusa. 500 diameters.

Fig. 26. The same as fig. 25. The cells of the outer wall of the tentacular bulb. 500 diameters.

Fig. 27. The same as figs. 25 and 26. Cells of the radiating canal brought out by fresh water. *a* face view; *b* in profile. 300 diameters.



A. Sonrel from nat' and on stone

I. H. Bradford & Co. print.

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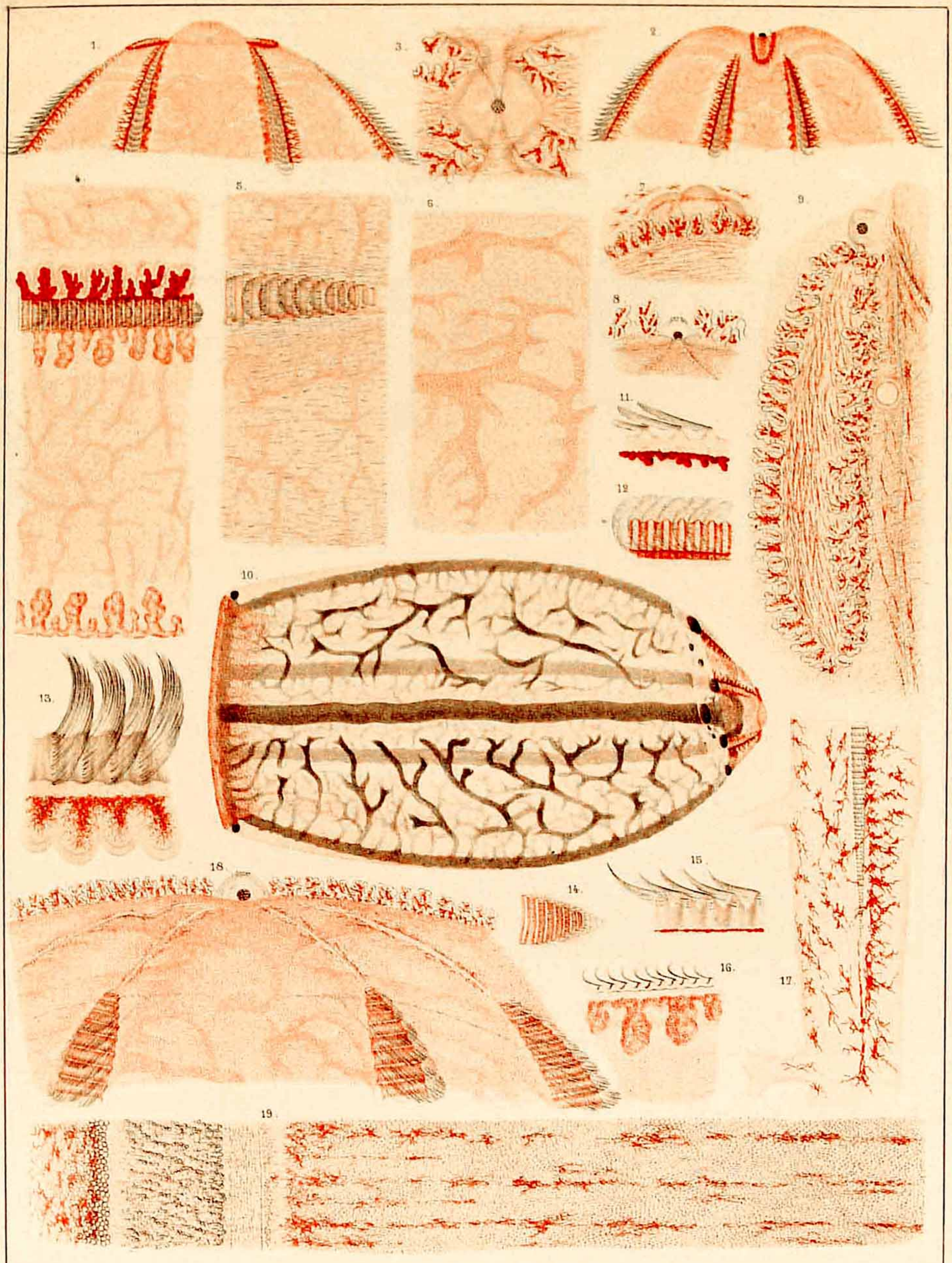

A. Sonrel from nat' & on stone.

Print. by L. H. Bradford & Co.

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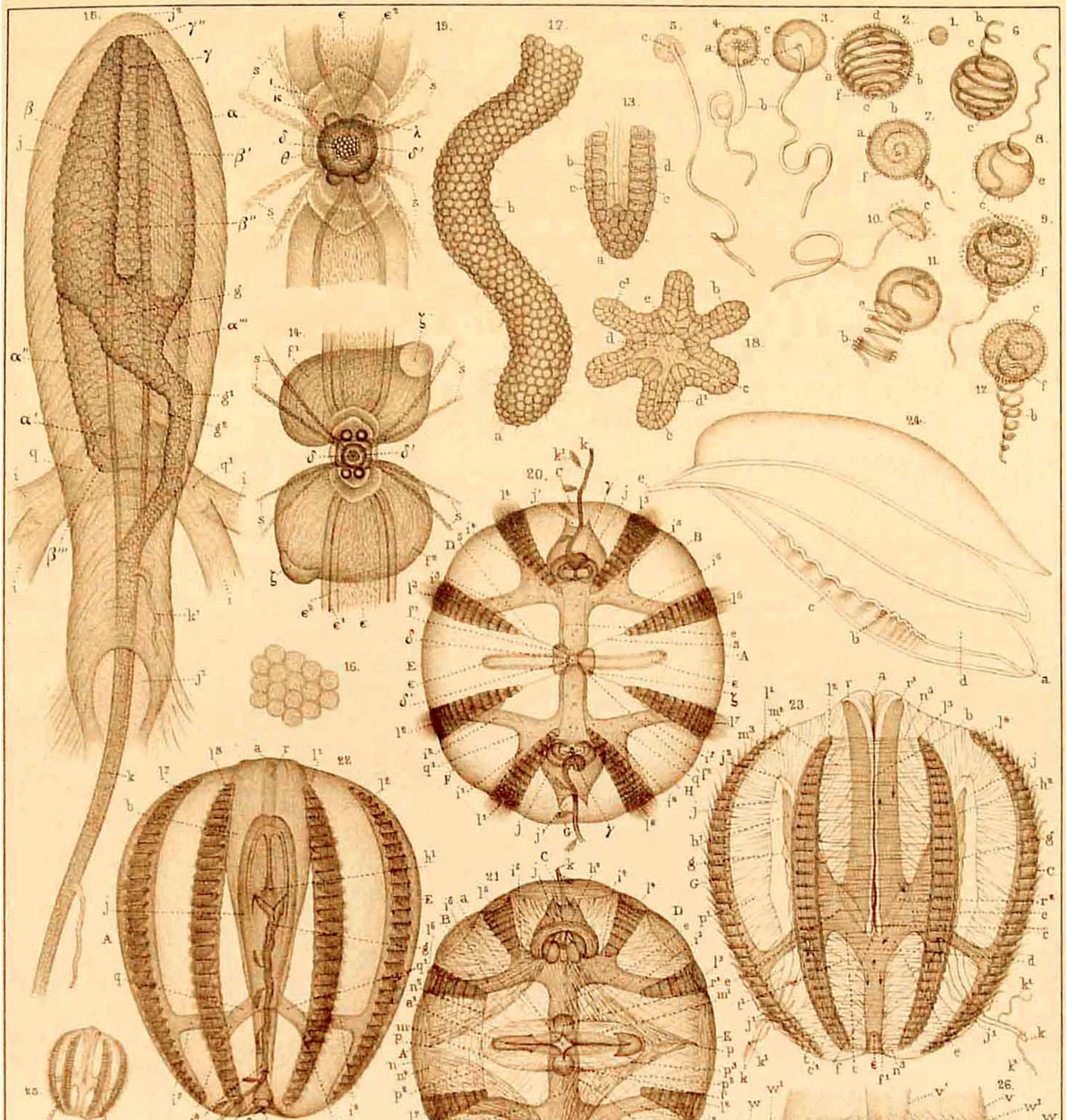

Clark from nat. Sonrel on stone. Printed at J. H. Bufford's

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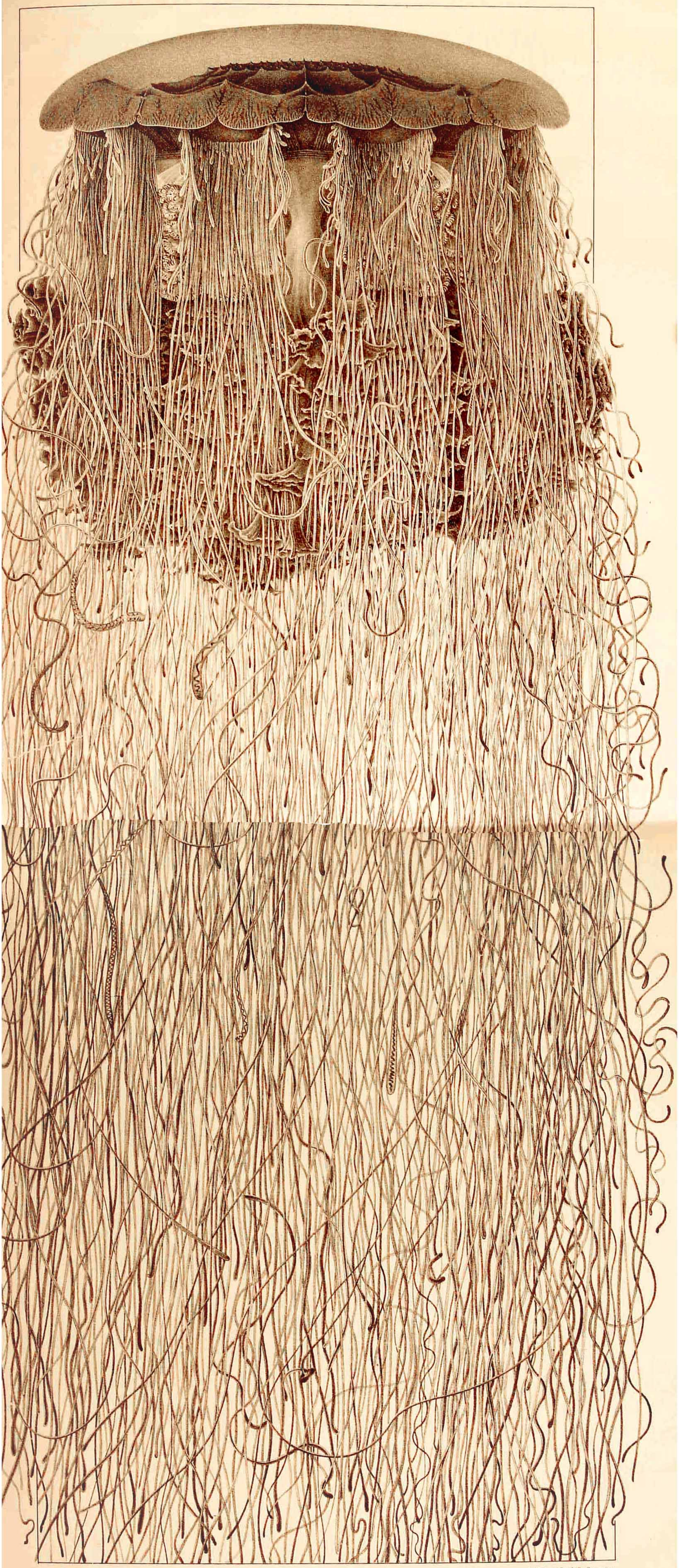
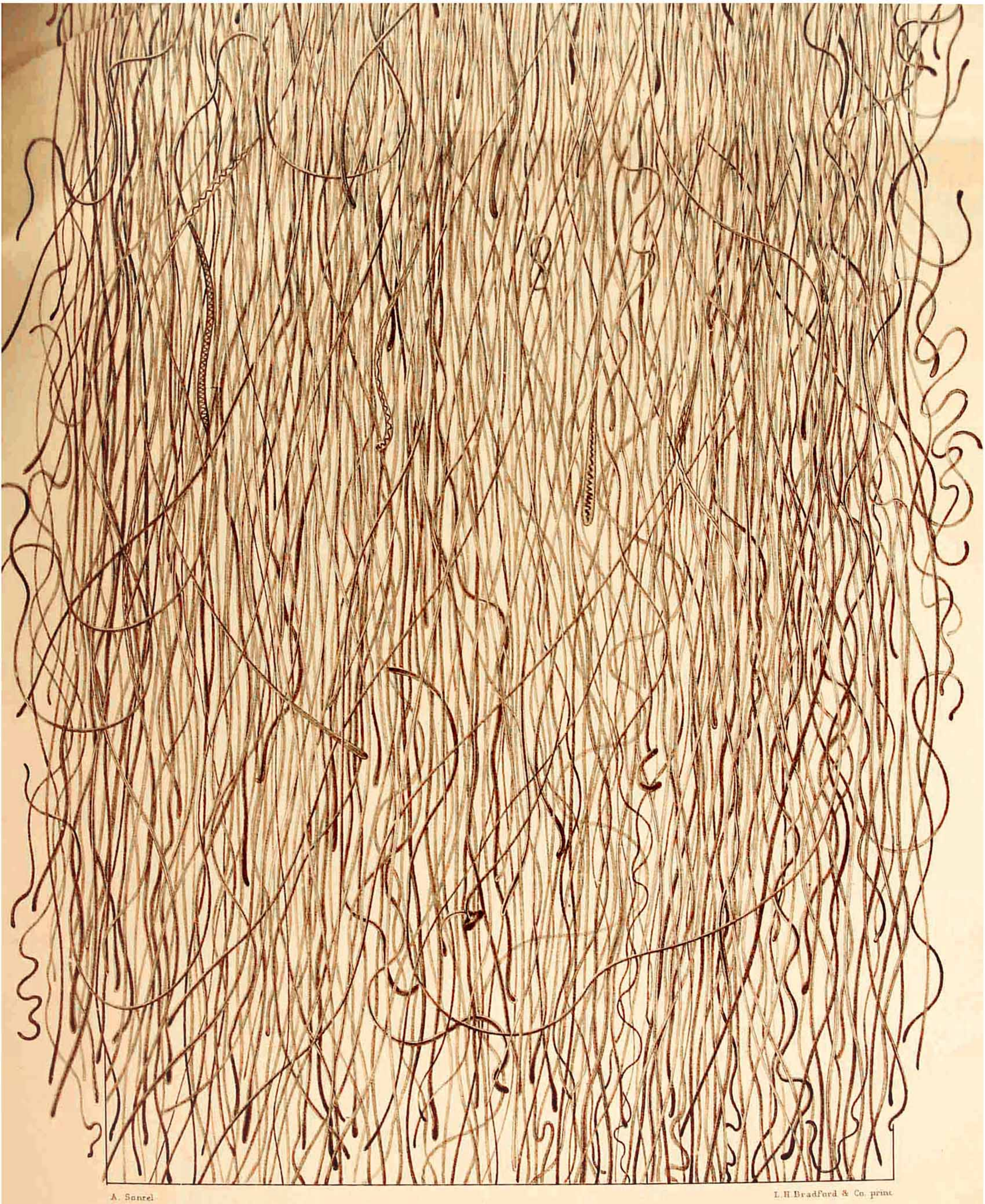


A. Sonrel. L. H. Bradford & Co. print.

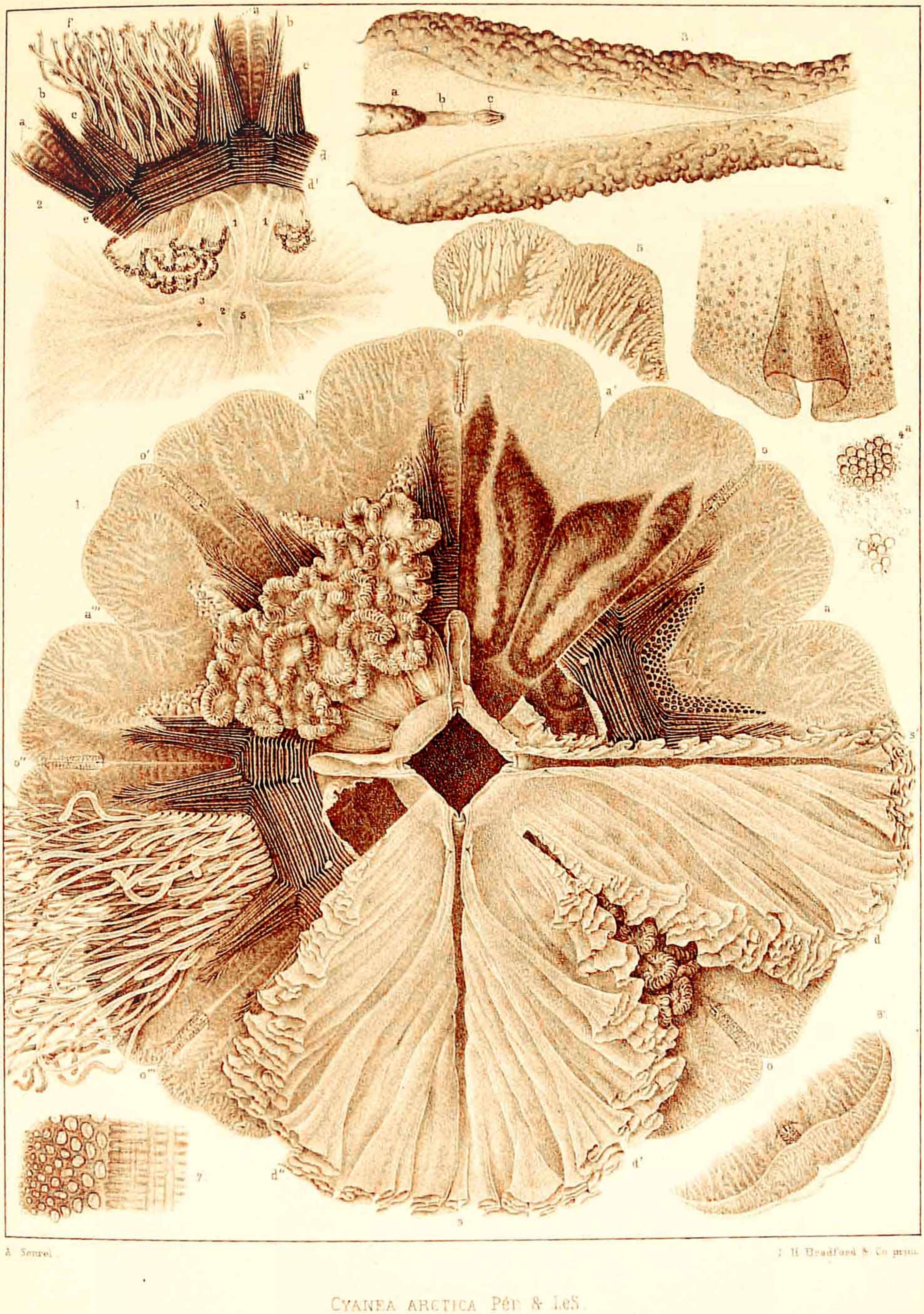
CYANEA ARCTICA Pér^t & Les^r



A. Sonrel

L. H. Bradford & Co. print.

CYANEA ARCTICA Pér.t & LeS.r



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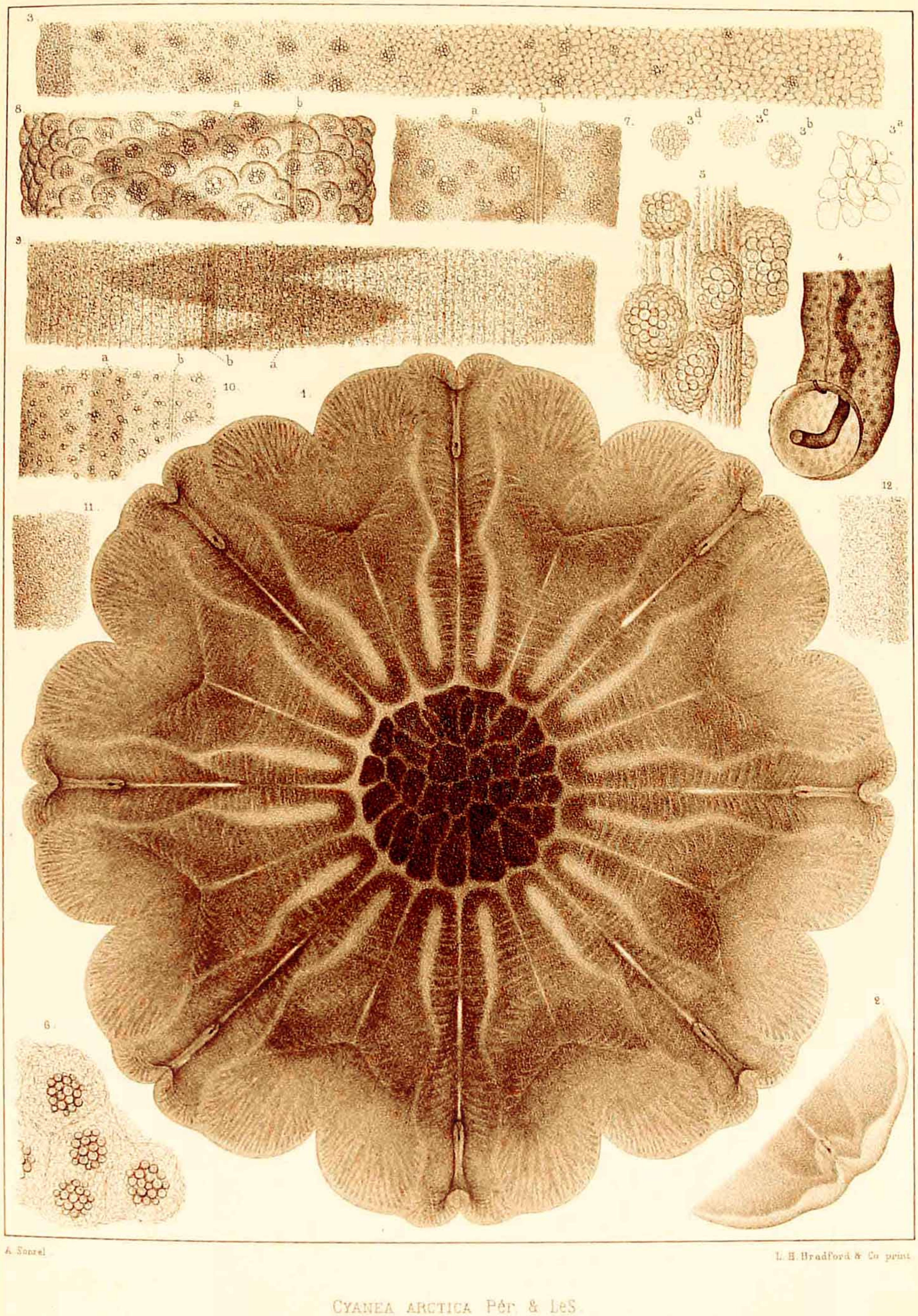


A. Sonrel

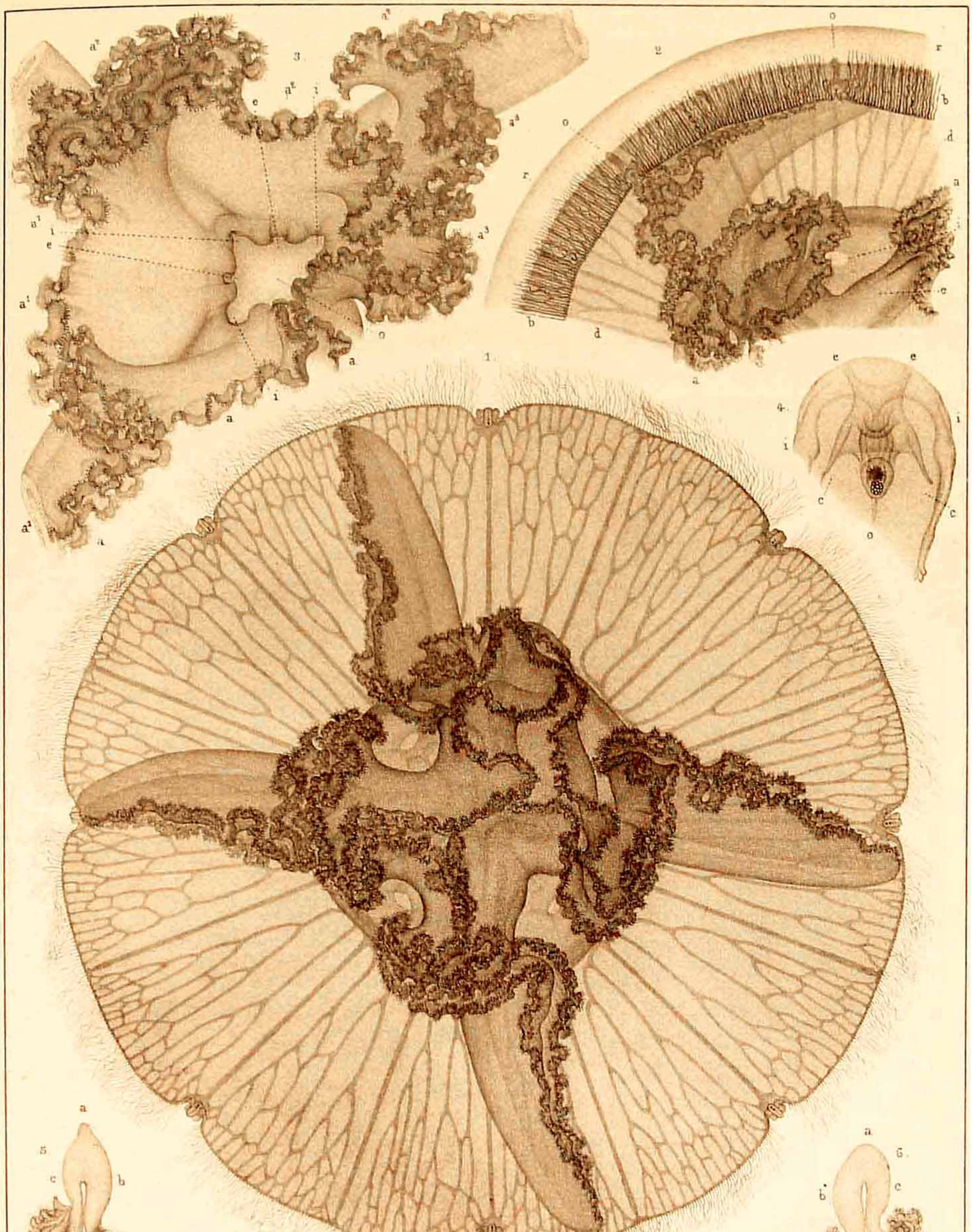
L. H. Bradford & Co. print.

CYANEA ARCTICA Pér. & LeS.

A. Sonrel from nat.

Printed by Meisel Bro.

CYANEA ARCTICA Pér. & LeS.



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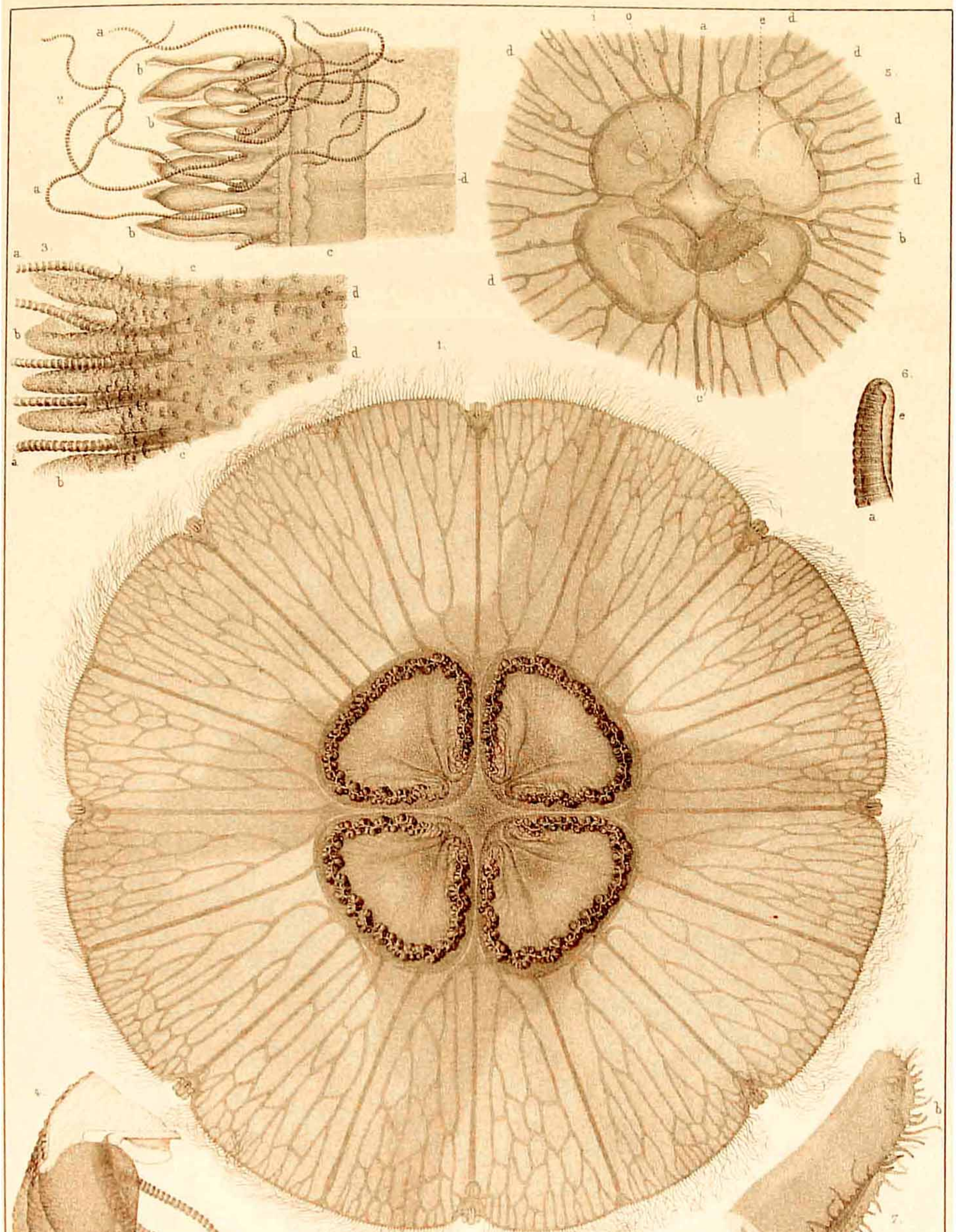
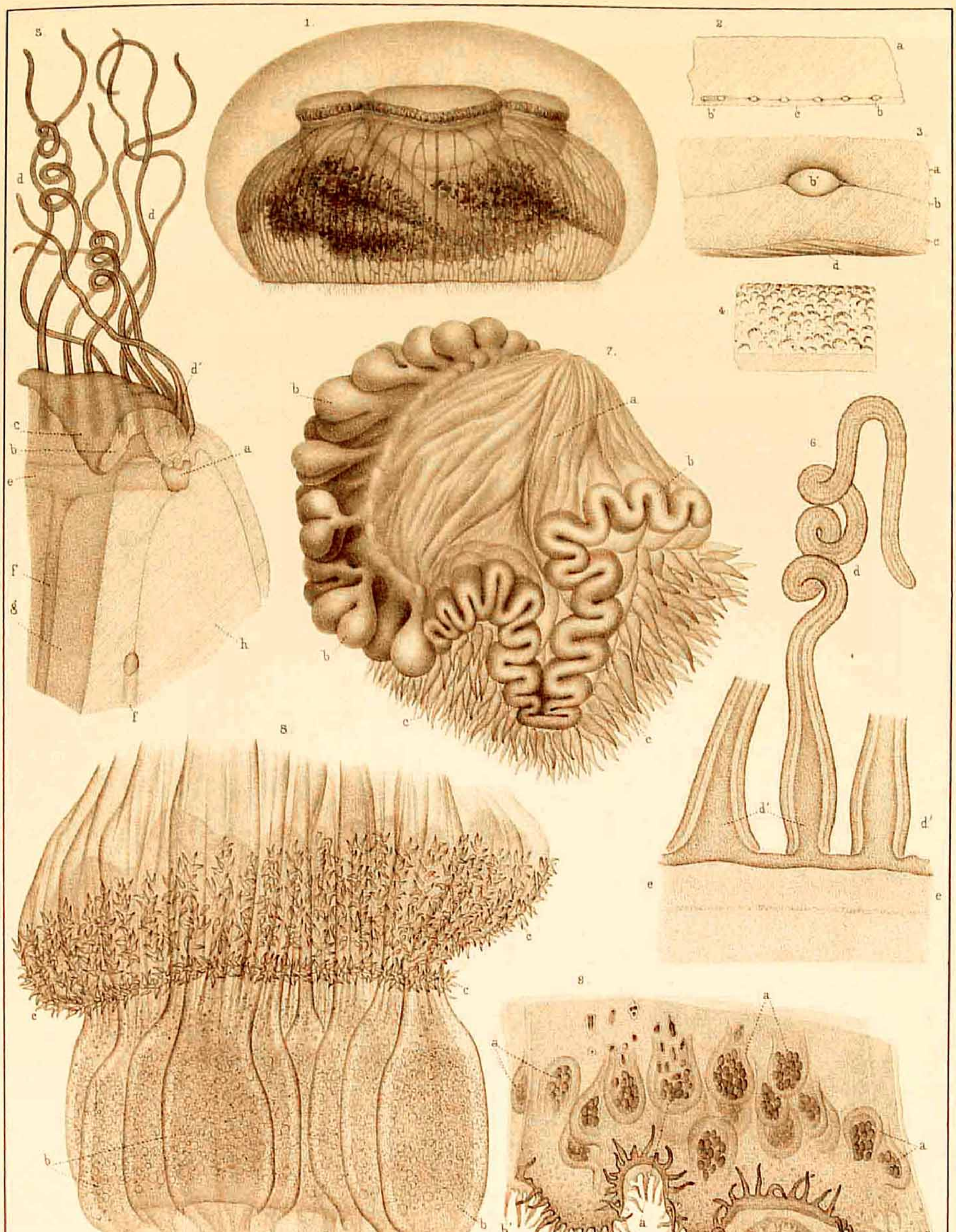
AURELIA FLAVIDULA Pér. & Les.



A. Sonrel L. H. Bradford & Co. print.

Aurelia flavidula Pér. & Les.



A. Sonrel. C.A. Evans, Print.

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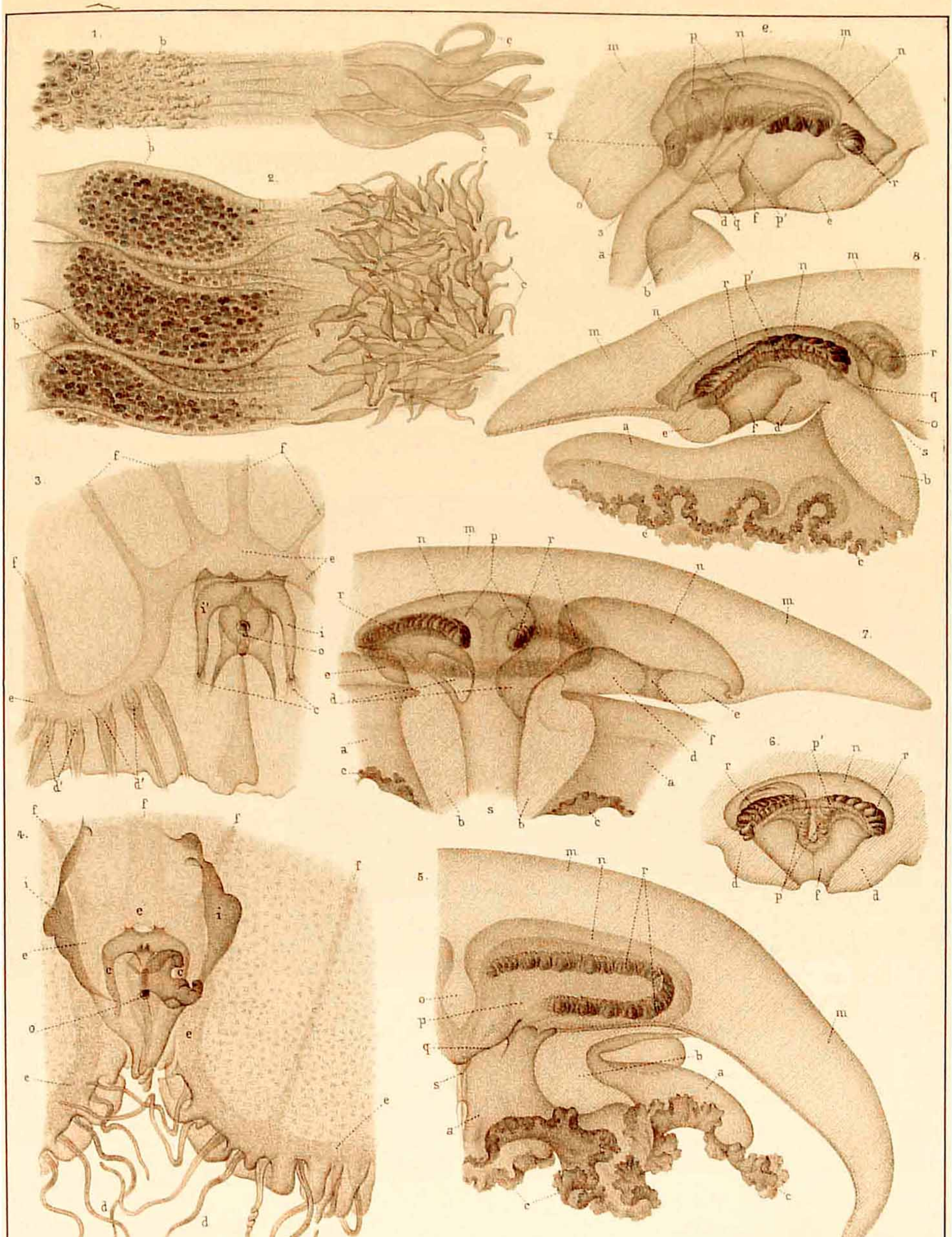

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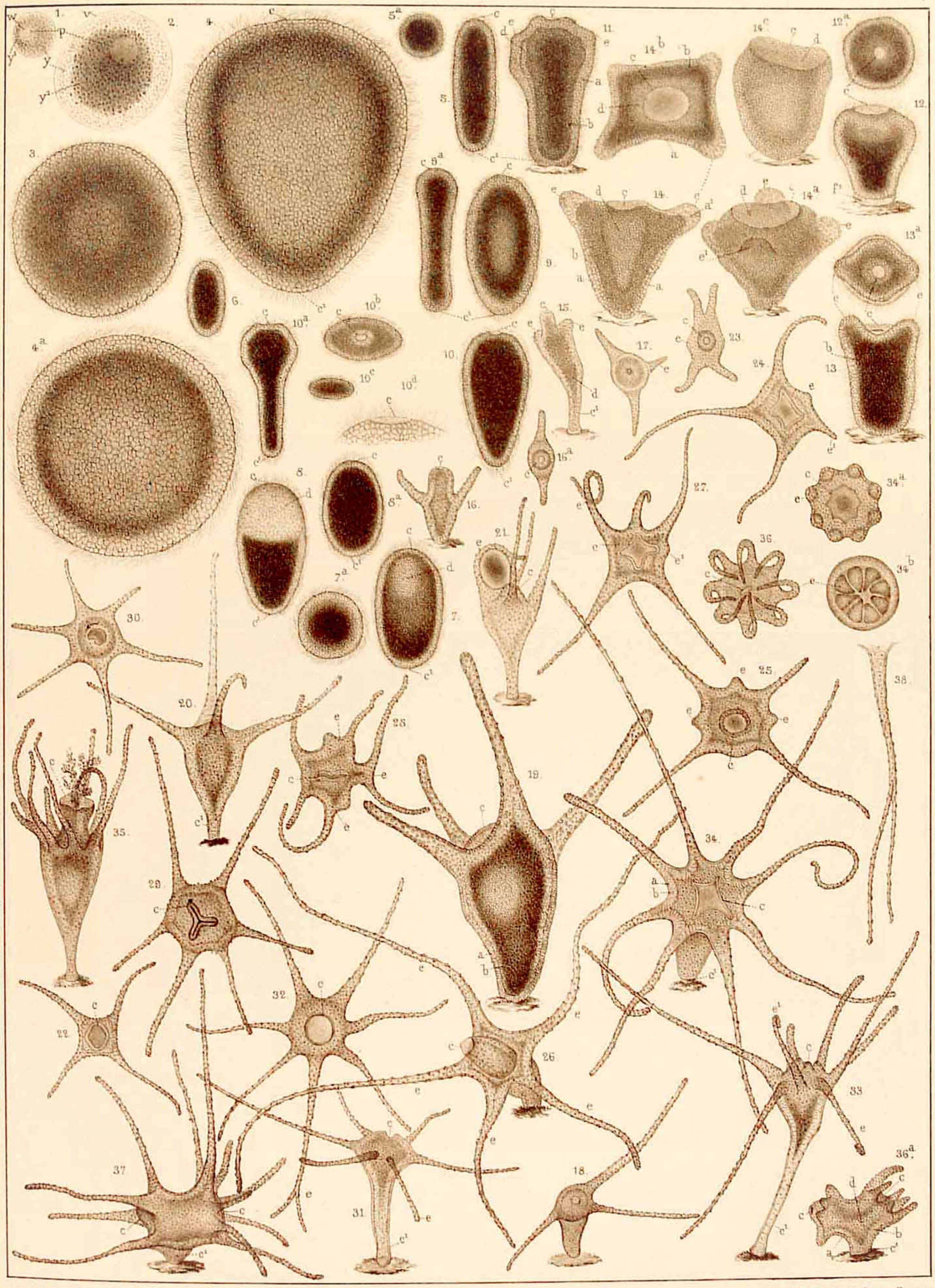
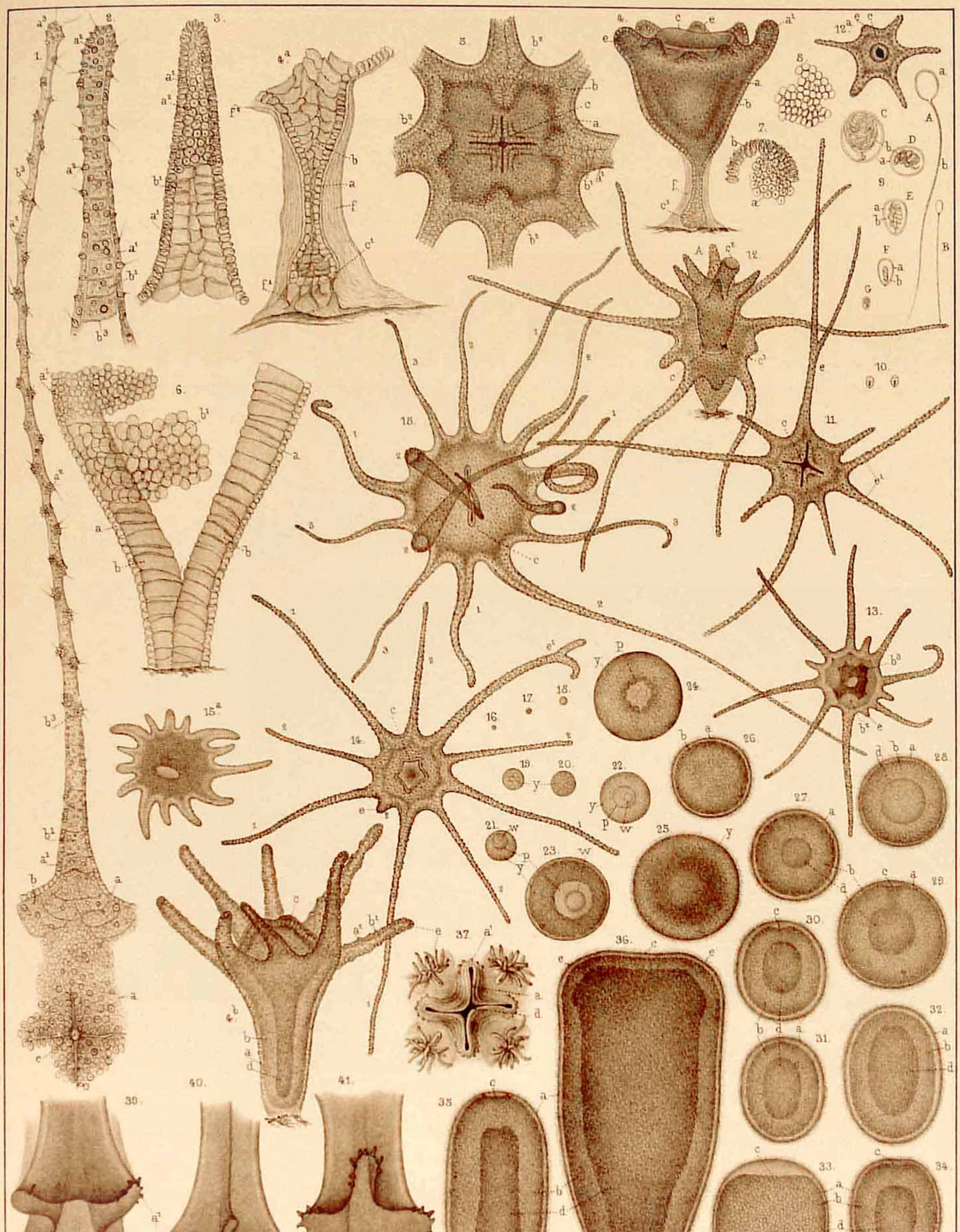


Clark from nat. Burrill on stone. J. H. Bufford's Print, Boston.

SCYPHOSTOMA OF CYANEA ARCTICA AND AURELIA FLAVIDULA.

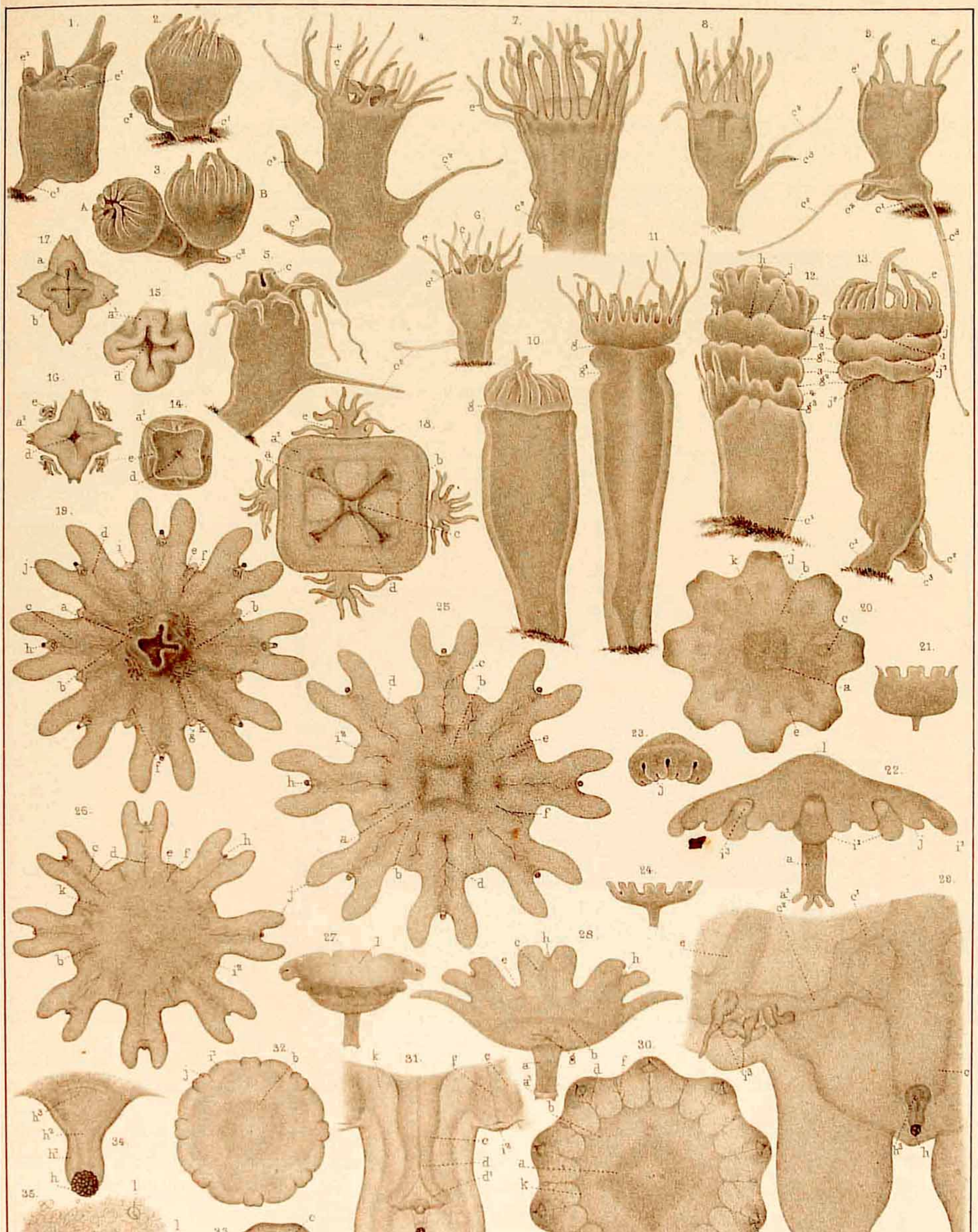


Clark & Sonrel from nat. J. H. Bufford's Print. Boston.

SCYPHOSTOMA OF CYANEA ARCTICA AND AURELIA FLAVIDULA.

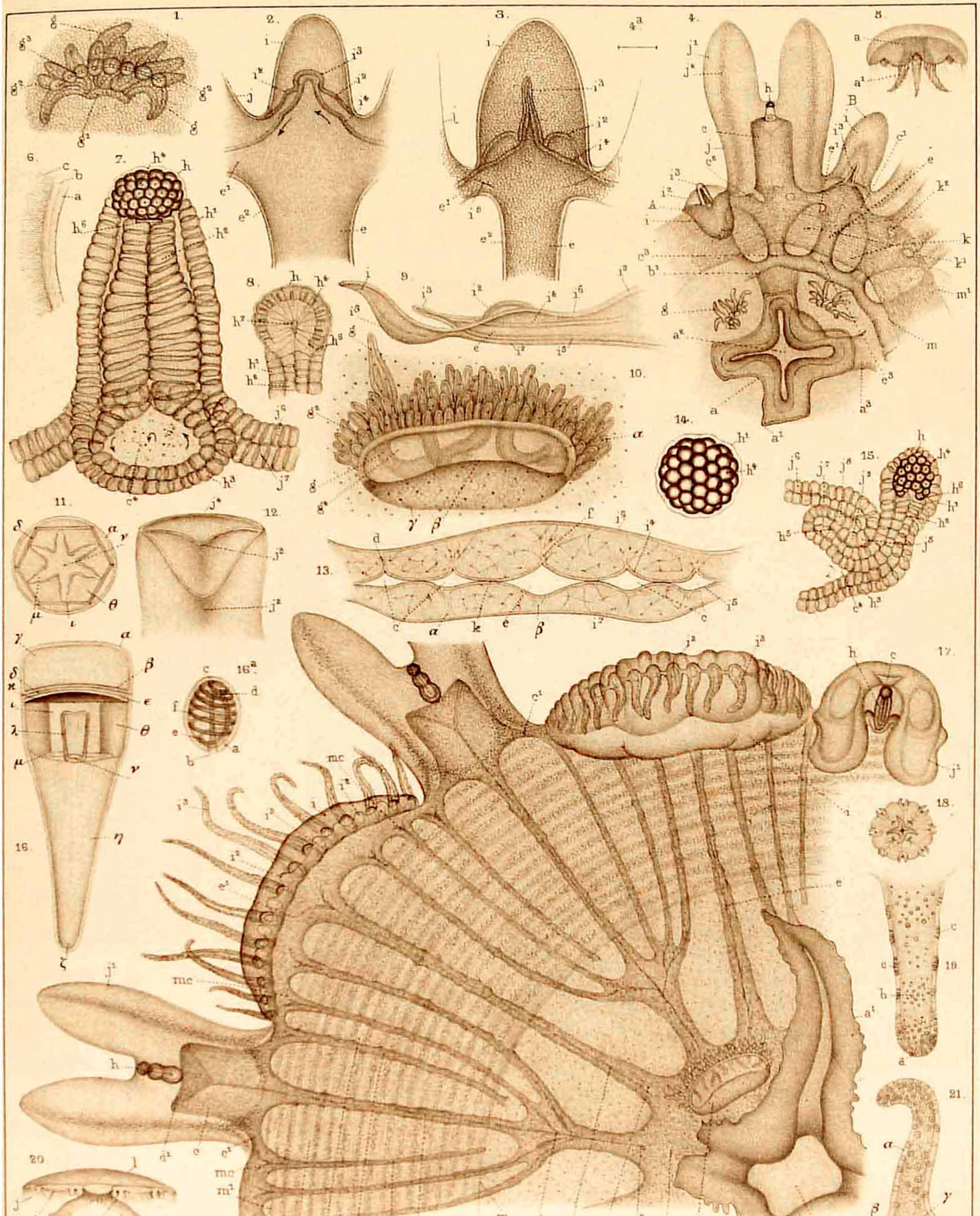
Sonrel from nat. Burrill on stone. L. H. Bradford & Co. print.

STROBILA OF AURELIA FLAVIDULA.



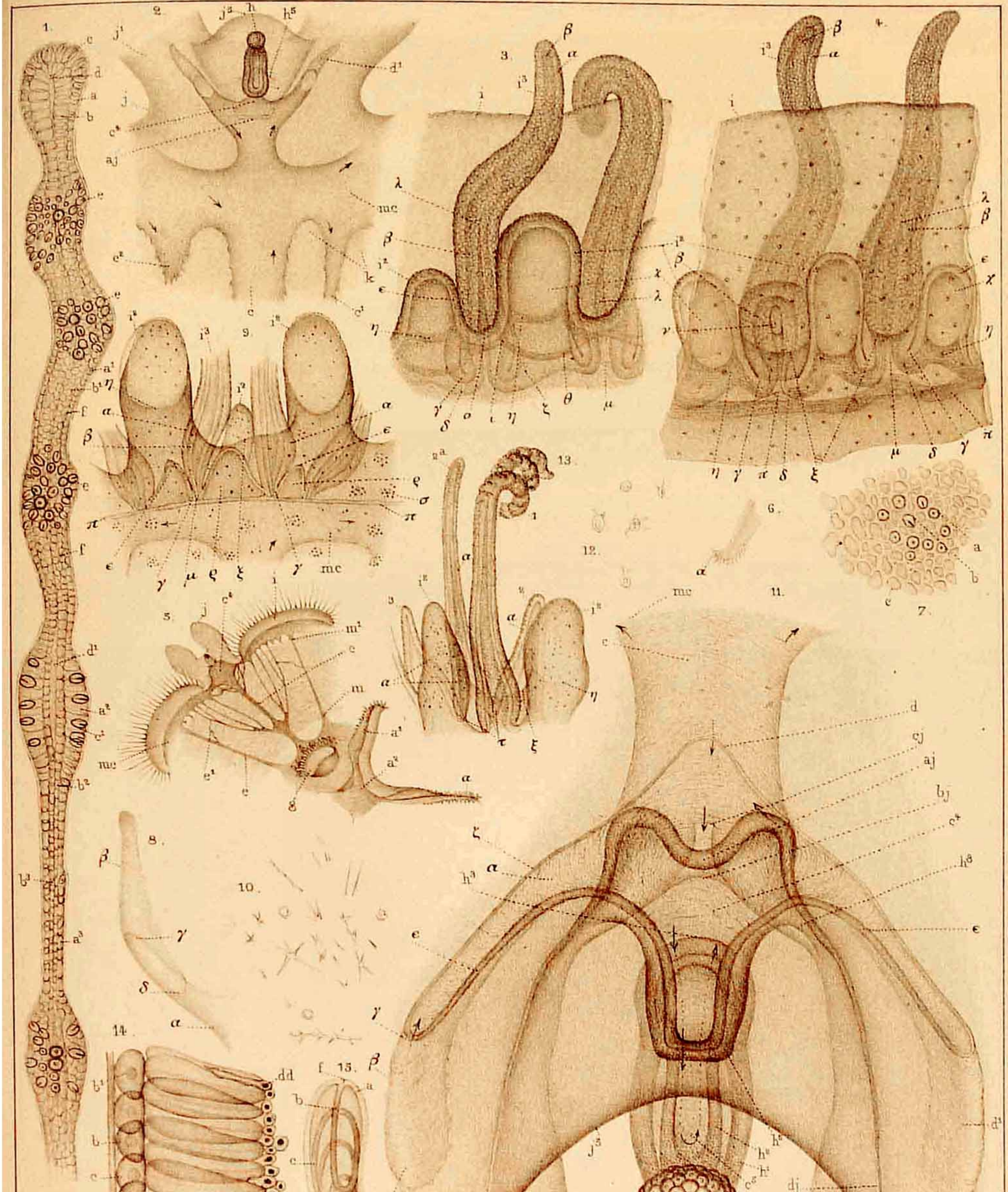
Sonrel from nat. Burrill on stone. L. H. Bradford & Co. print.

SCYPHOSTOMA AND EPHYRA OF AURELIA FLAVIDULA.



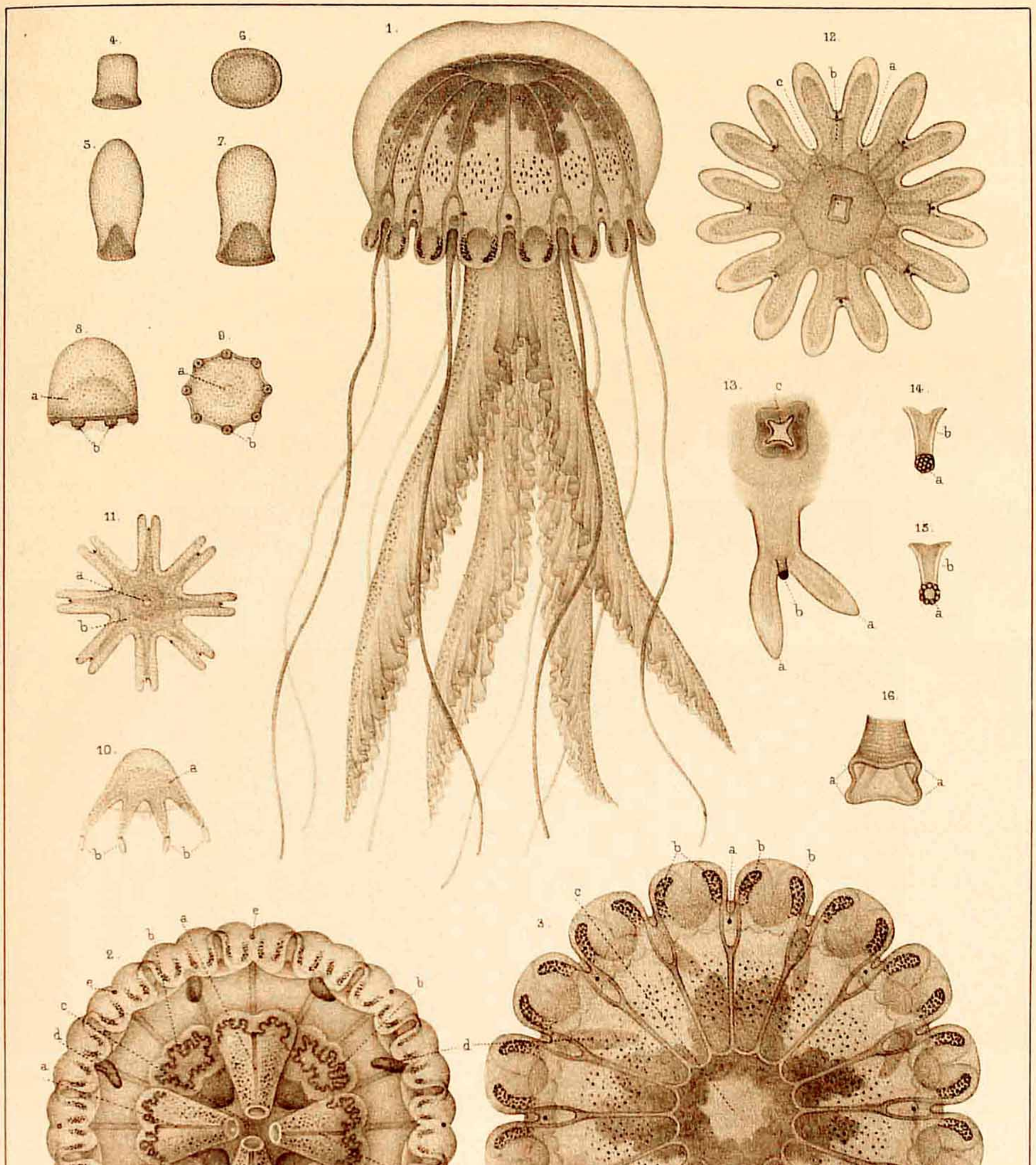
H. J. Clark from nat. Print. at J.H. Buffords Boston A. Sonrel on stone.

EPHYRA OF AURELIA FLAVIDULA.



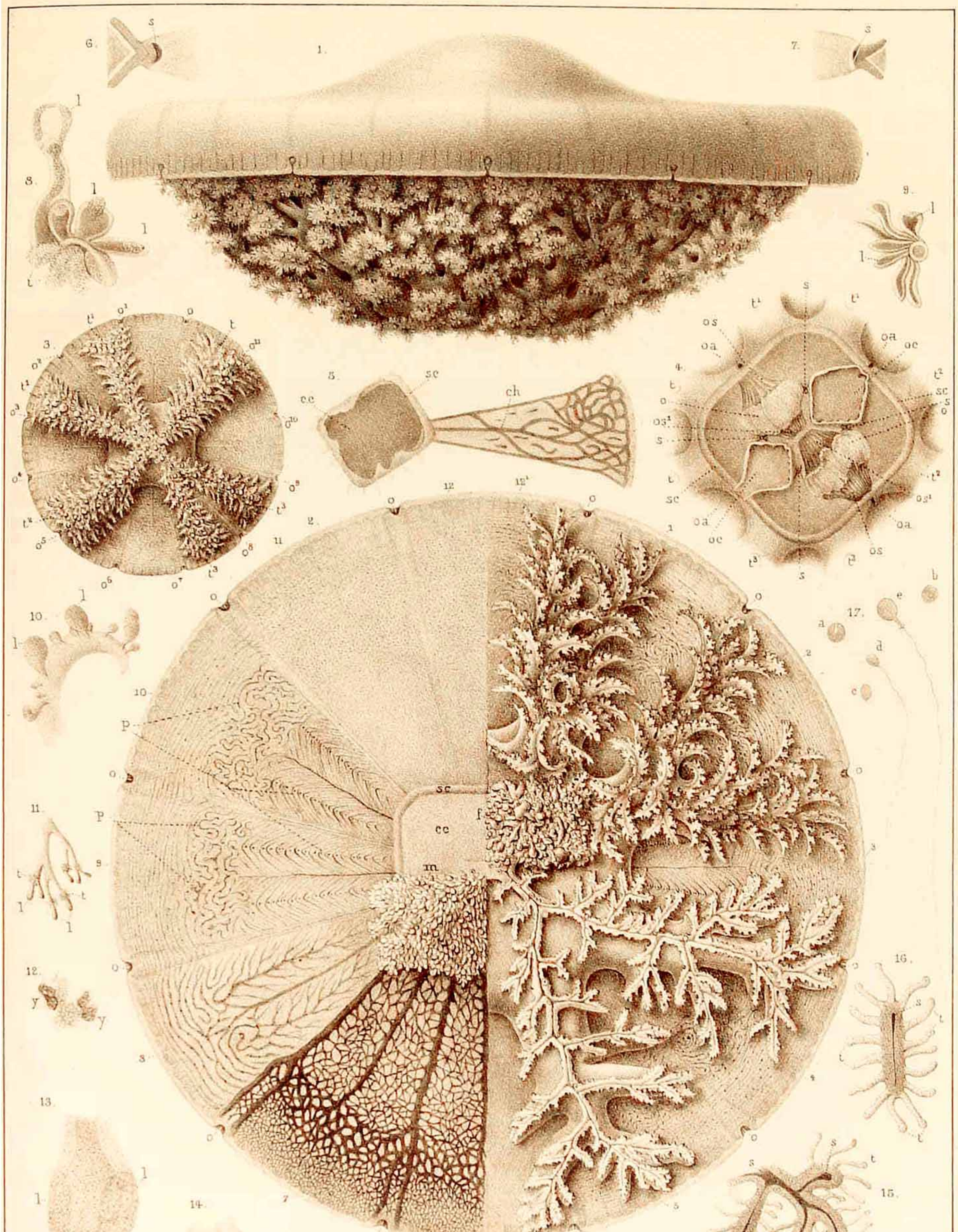
B. J. Clark from nat. Print. at J. H. Bufford's Boston. A. Sonrel on stone.

AURELIA FLAVIDULA (EPHYRA) AND CORYNE MIRABILIS.



J. Burkhardt from nat. A. Sonrel on stone. L. H. Bradford & Co. print.

PELAGIA CYANELLA Pér. & Les.



J. Burkhardt from nat.

Printed at J.H. Bufford's Boston.

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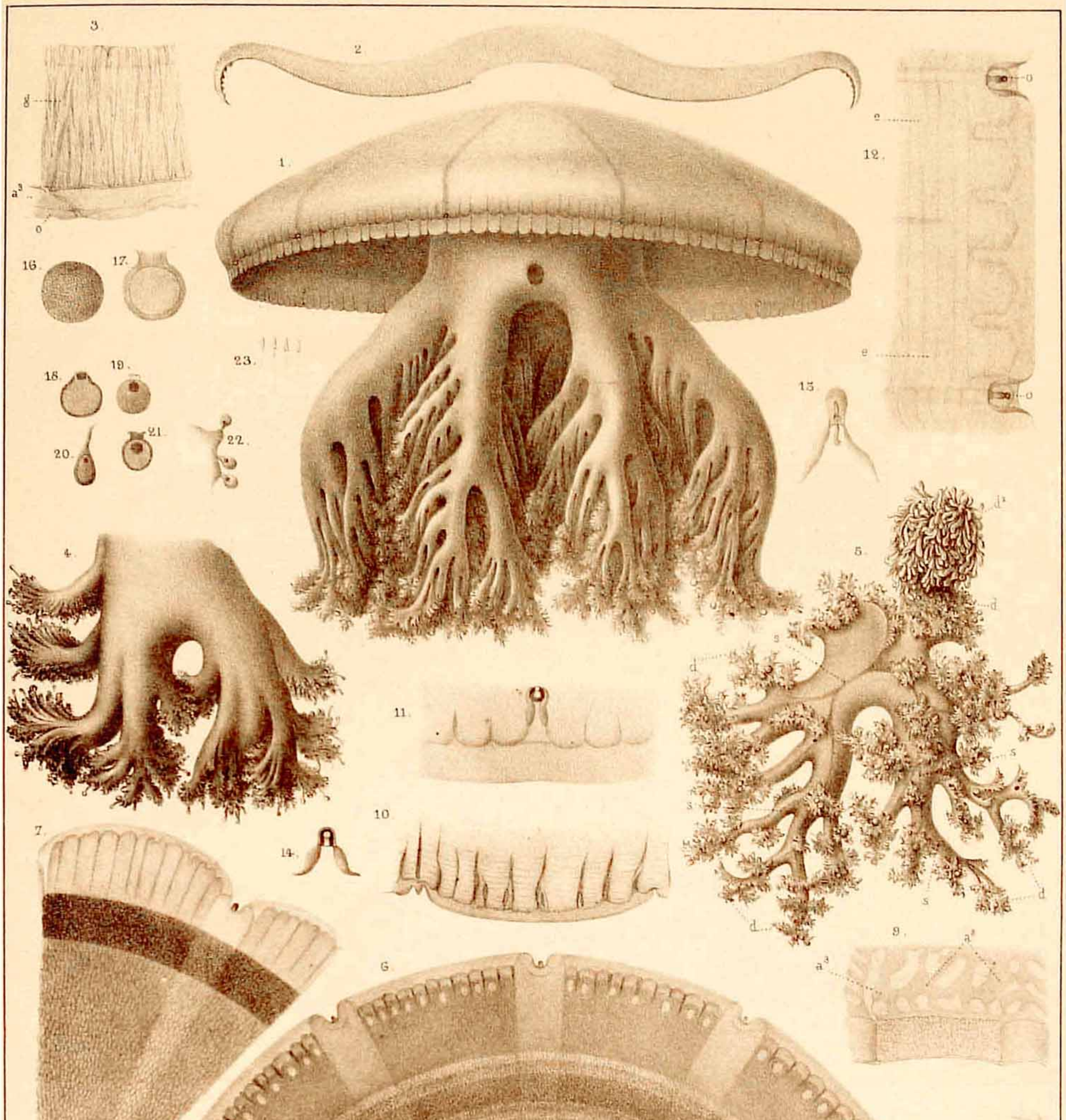

J. Burkhardt from nat' Printed by Meisel Bro's

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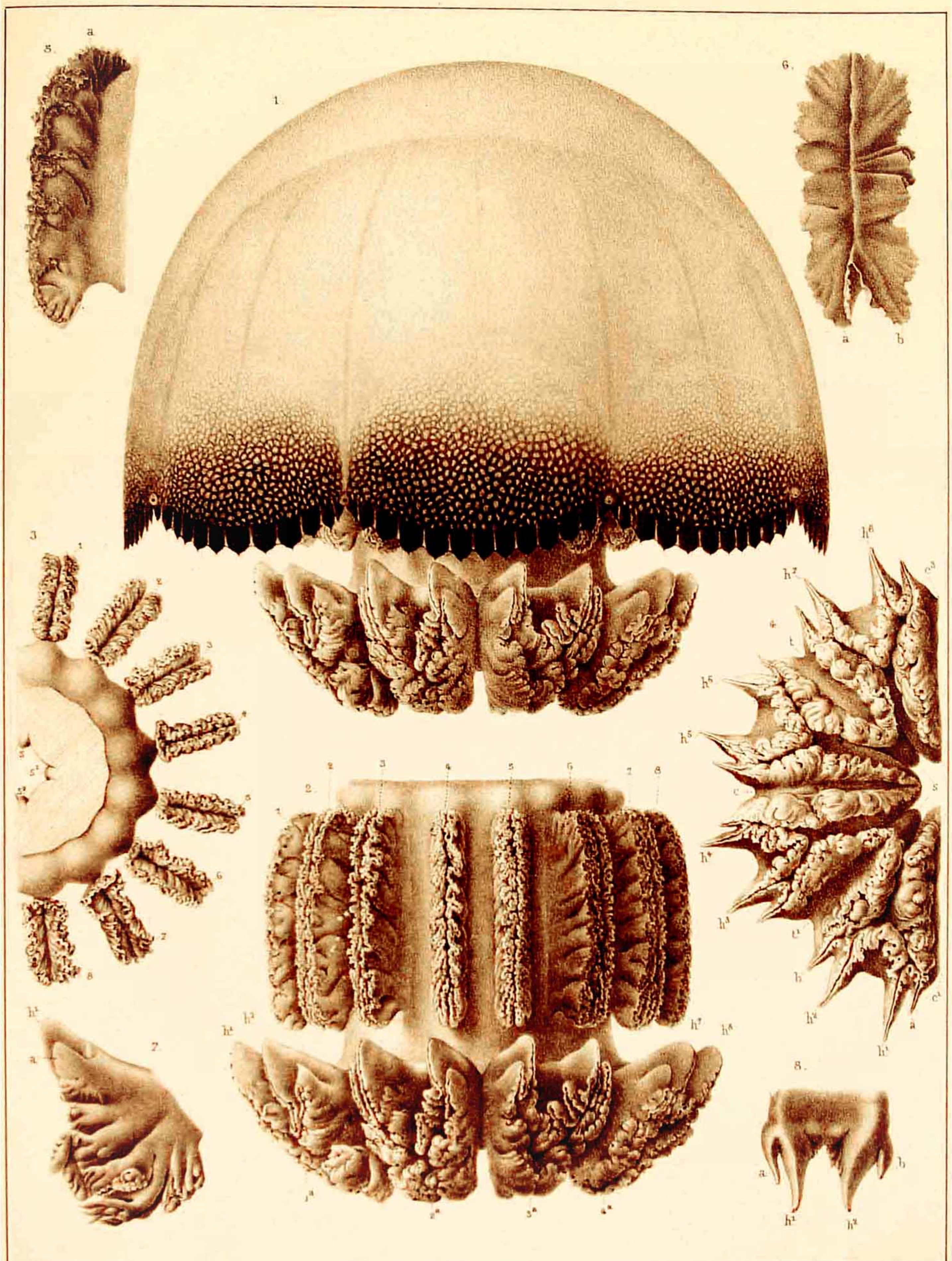
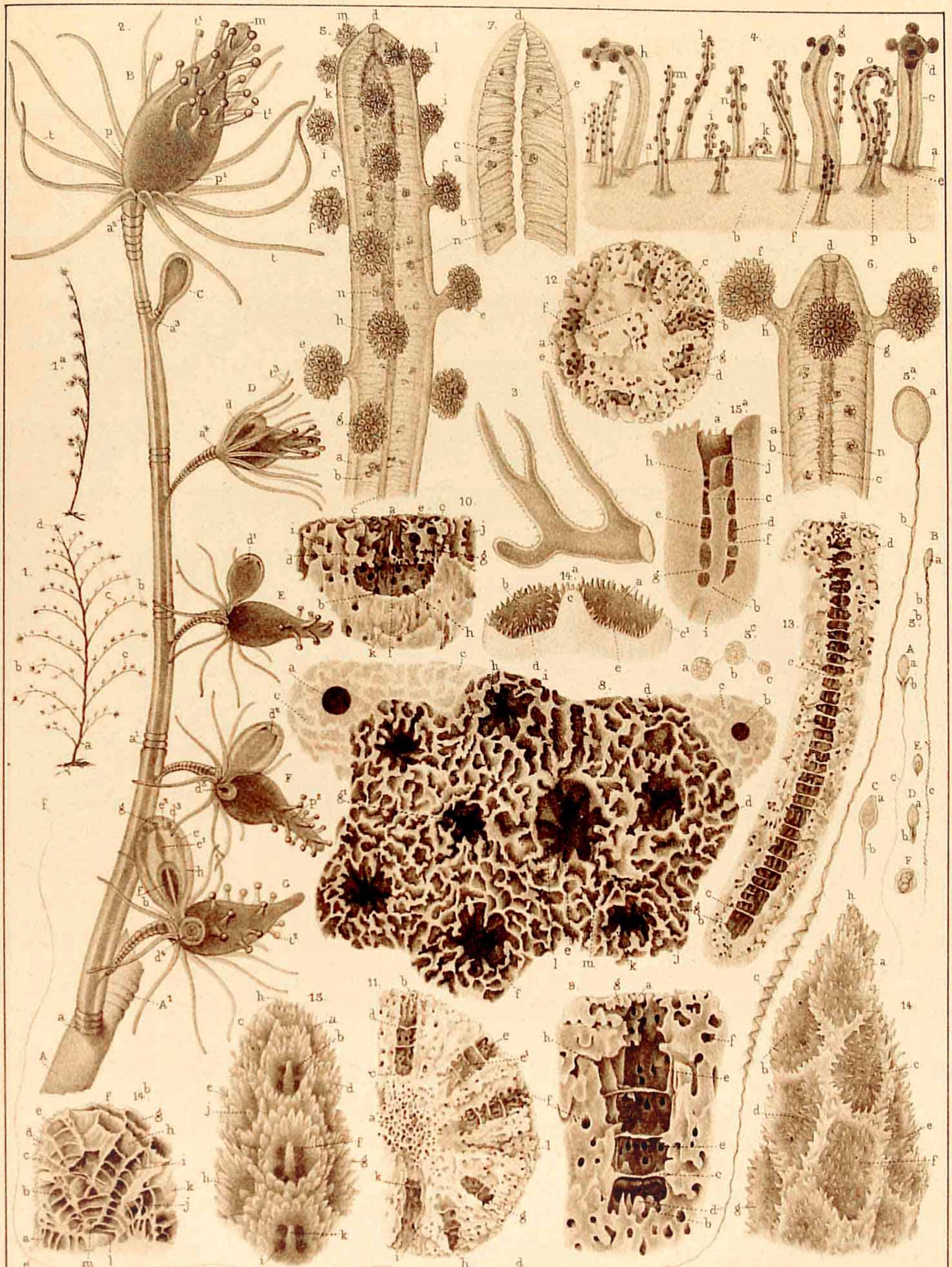


Sonrel & Burkhardt from nat.

Printed at J. H. Bufford's Boston.

Stomolophus Meleagris Ag.



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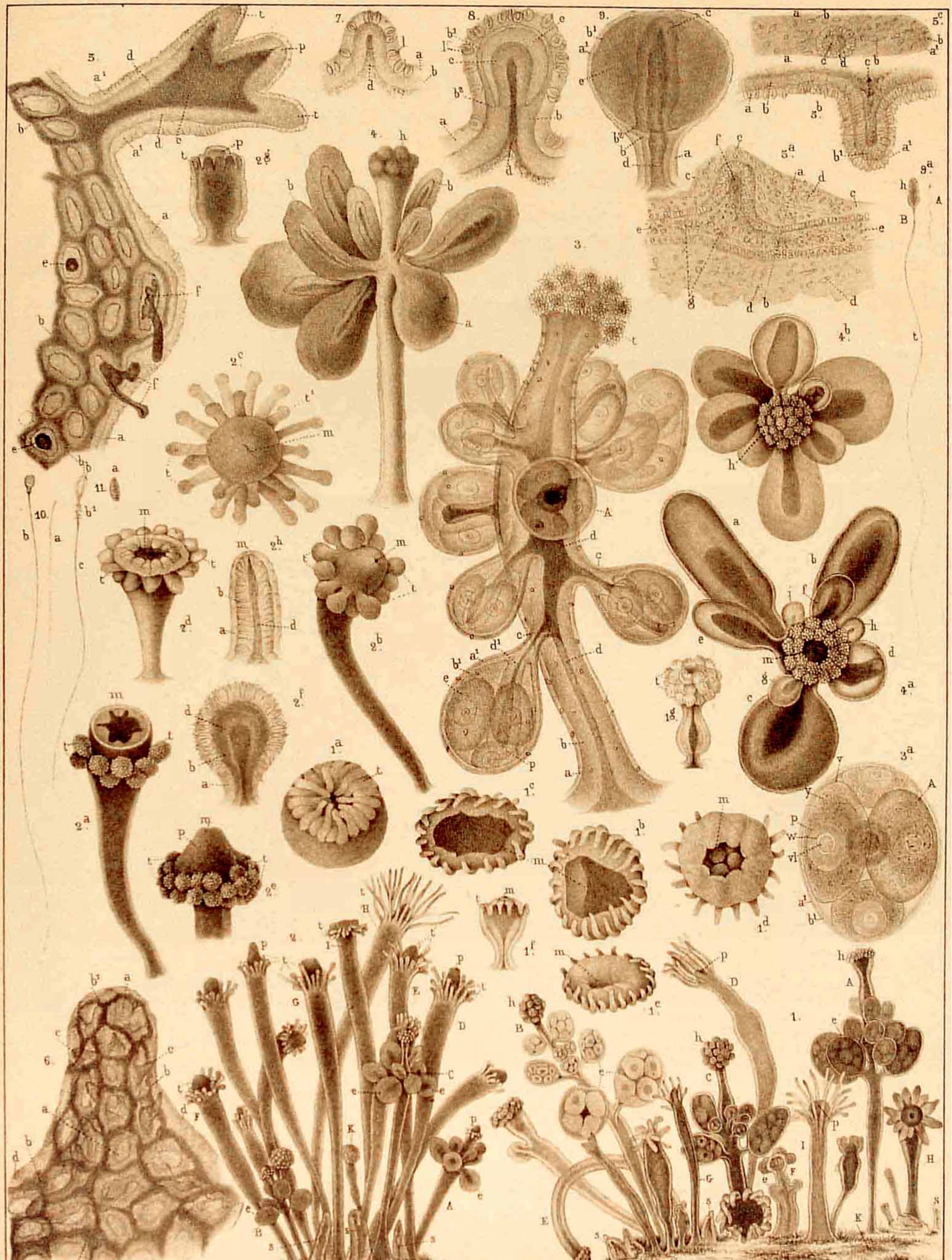
1 & 2. PENNARIA GIBBOSA Ag. — 3-13. MILLEPORA ALCICORNIS Linn.



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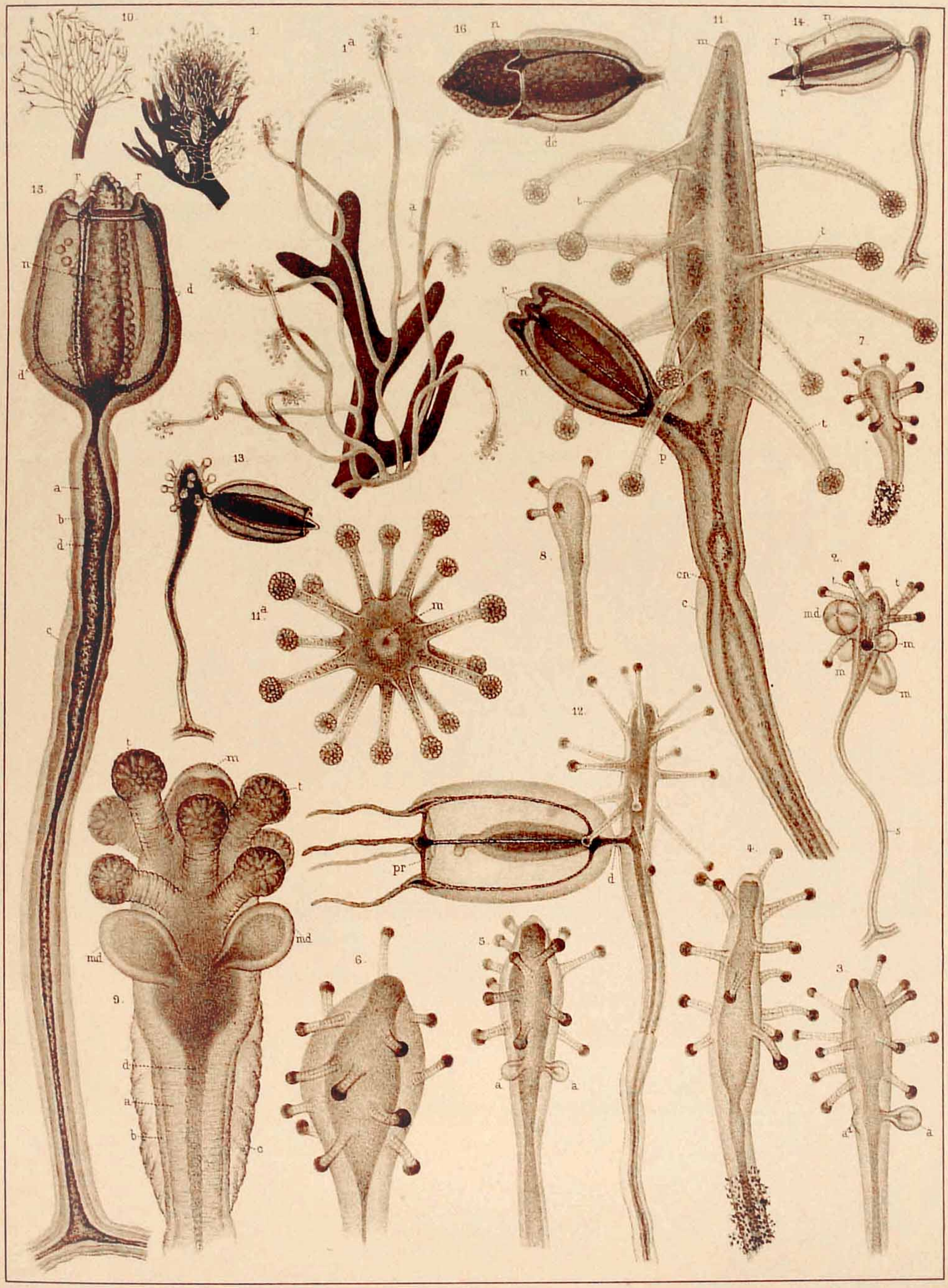

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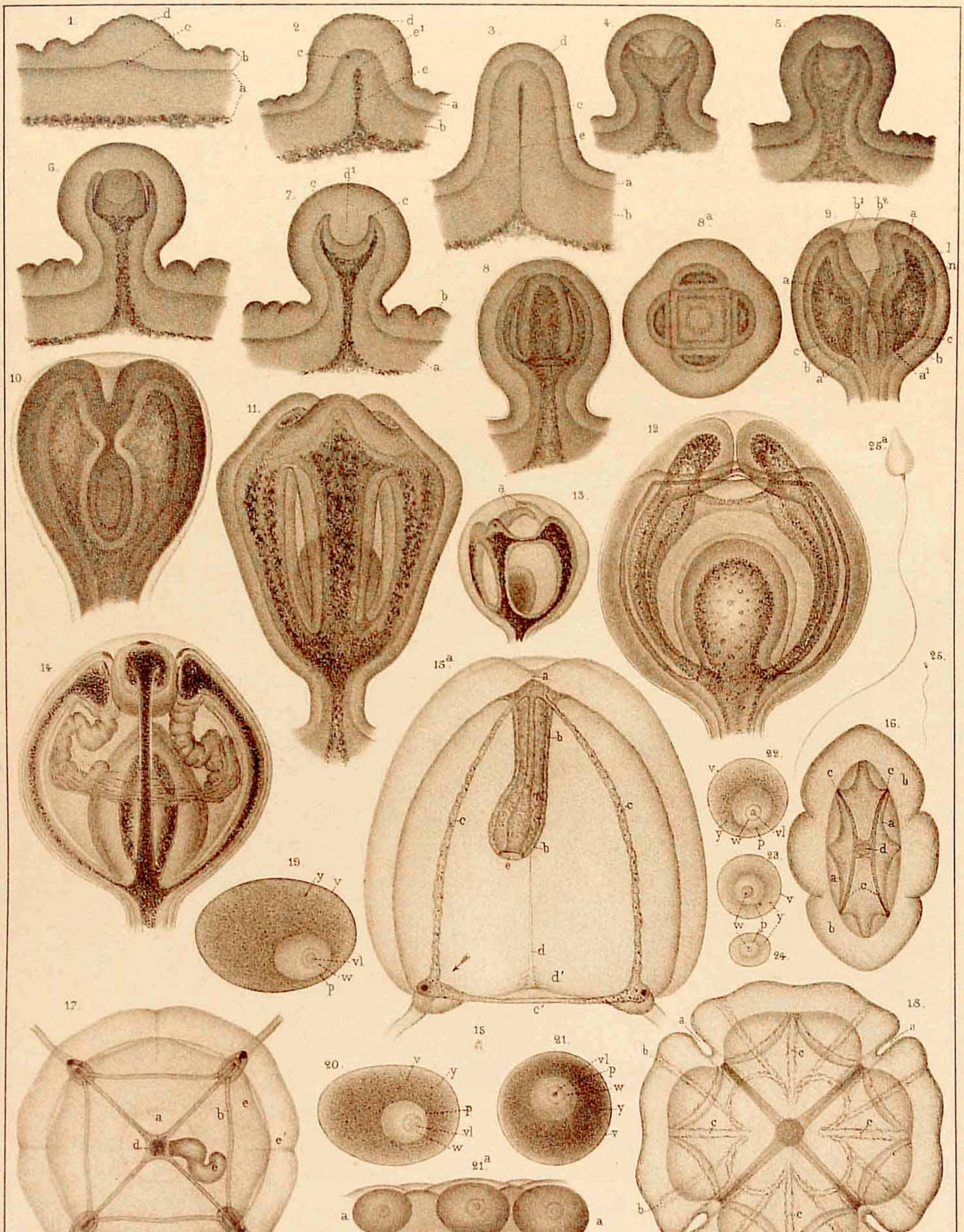
L. H. Bradford & Co print.



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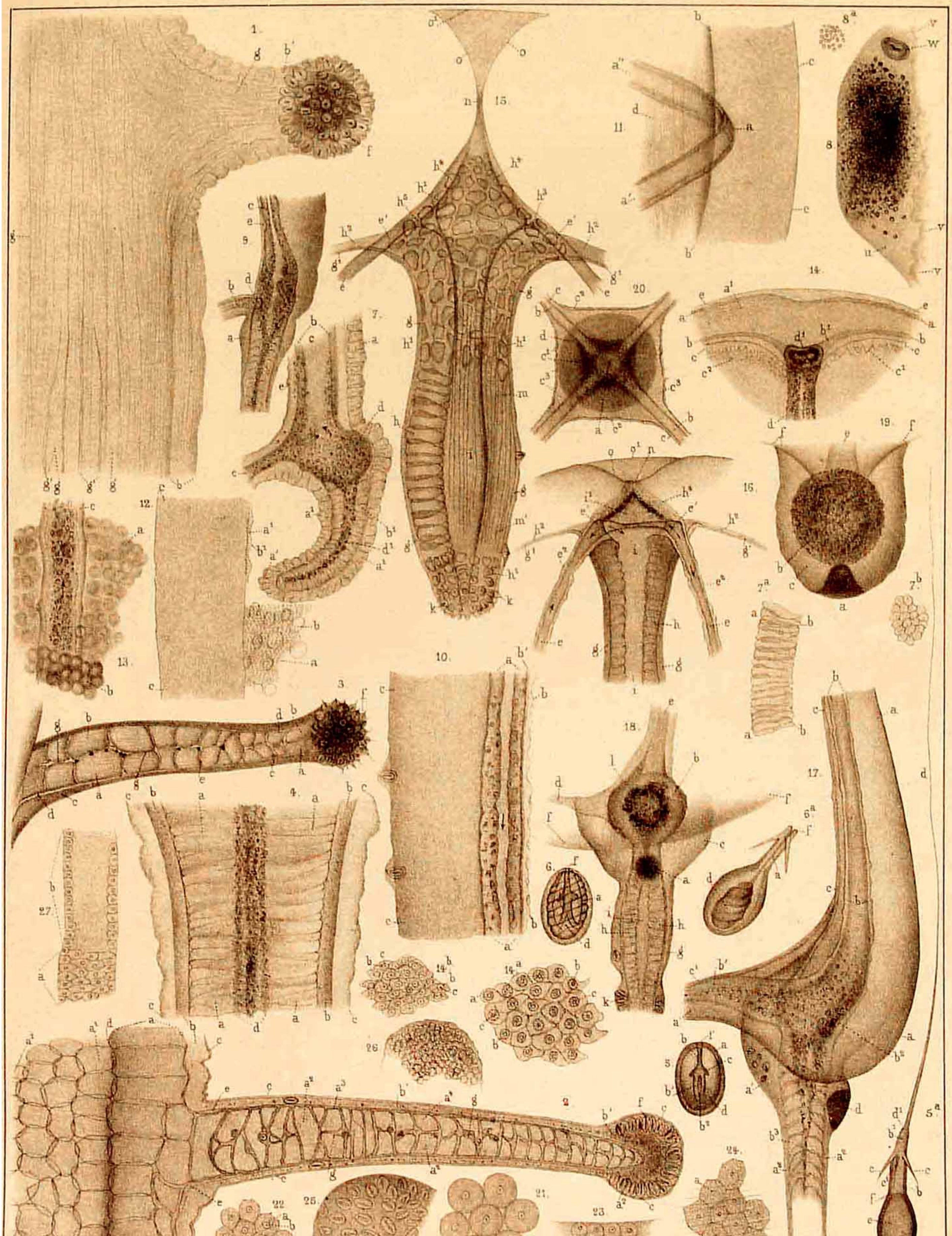
CORYNE MIRABILIS Ag.



H. J. Clark from nat.

L. H. Bradford & Co. print.

CORYNE MIRABILIS Ag.