THE

# MEDALS OF CREATION;

OR,

# FIRST LESSONS IN GEOLOGY,

AND IN THE STUDY OF

# Organic Remains.

BY

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AUTHOR OF THE WONDERS OF GEOLOGY.

ETC.

*Henry Carr, Esq. C. E. delt.* *J. Whimper, lign.*

INCLINED STRATA OF MILLSTONE GRIT. CRICH HILL.

"It is not one of the least advantages of these pursuits, that they are altogether independent of external circumstances, and may be enjoyed in every situation in which a man can be placed in life."—Sir J. F. W. HERSCHEL, *On the Study of Natural Philosophy.*

IN TWO VOLS.—VOL. II.

CONTAINING

FOSSIL CEPHALOPODA, CRUSTACEA, INSECTS, FISHES, REPTILES, BIRDS, AND MAMMALIA,

WITH

NOTES OF GEOLOGICAL EXCURSIONS.

LONDON:

HENRY G. BOHN, YORK STREET, COVENT GARDEN.

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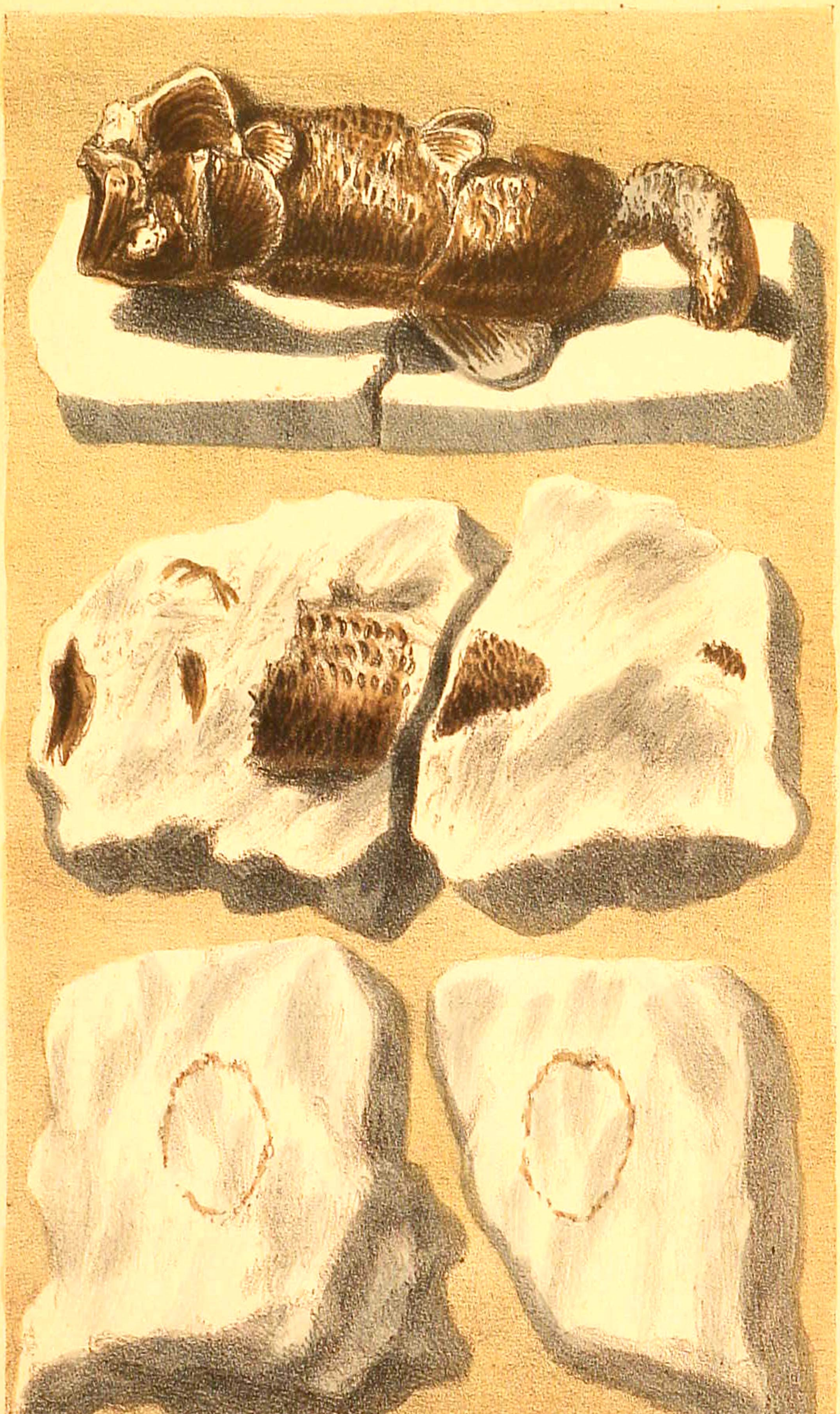
Pl. 2.



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J. Dinkel del. G. Scharf lithog.

## DESCRIPTION OF PLATE II.

*The Frontispiece of Vol. II.*

A Fossil Fish of the SALMON tribe, allied to the SMELT; from the Chalk, near Lewes, in Sussex.

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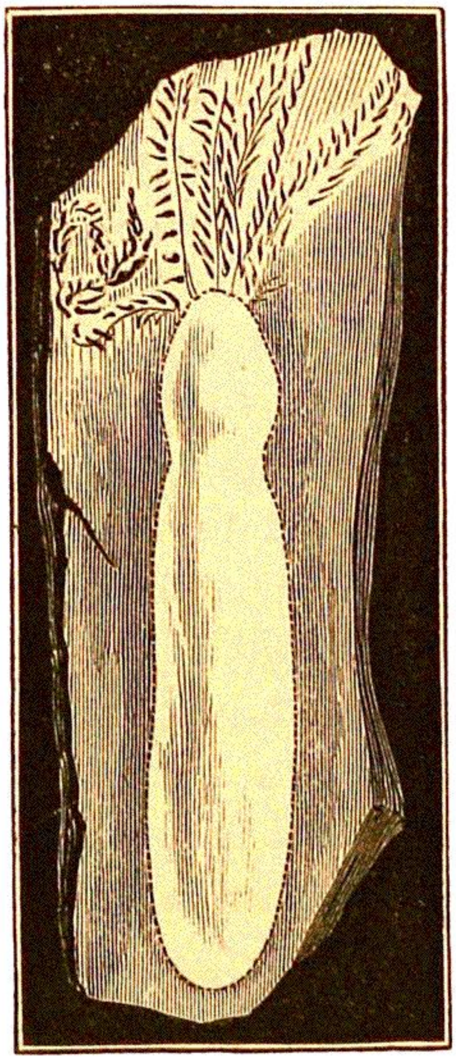
THE

# MEDALS OF CREATION.

## CHAPTER XIII.

### FOSSIL CEPHALOPODA; COMPRISING THE BELEMNITIDÆ, NAUTILIDÆ, AND AMMONITIDÆ.



LIGN. 100. FOSSIL SEPIA, OR CUTTLE-FISH: $\frac{1}{3}$ *nat.* (*M. D'Orbigny.*) *Solenhofen.*
(KELIANO SPECIOSA. *Count Munster.*)
The impression of the body, head, and arms, or tentacula, with their clasps.

THE molluscous animals named *Cephalopoda*, (from their organs of prehension being arranged around the upper part of the body), are the most ancient, numerous, and interesting of this division of animated nature; and their fossil remains comprehend the most varied and striking forms of extinct beings that occur in the sedimentary strata, from the earliest Secondary to the latest Tertiary formations. The living species are but a feeble representation of the countless myriads which swarmed in the ancient seas; yet they afford important assistance in developing the characters of the numerous extinct genera, whose relics abound in the strata, and will continually be presented to the observation of the collector. It is therefore necessary to enter somewhat in detail on the structure of these beings, that the student may obtain a correct idea of the nature of the curious fossils, to which the mineralized remains of the durable parts of these animals have given rise, and whose origin has but lately been correctly ascertained. These mollusca are composed of a body which is either enclosed in a shell, as in the *Nautilus*, or contains a calcareous or cartilaginous part, as in the *Sepia*, or cuttle-fish; with a distinct head, and eyes as perfect as in the vertebrate animals; complicated organs of hearing; a powerful manducatory apparatus, surrounded by arms, or *tentacula*, serving for prehension.* They have below the head a tube which acts as a locomotive instrument to propel the animal backwards, by the forcible ejec-

* See a masterly notice of the Cephalopoda, in Professor Owen's Hunterian Lectures. 1843.

tion of the water that has served the purposes of respiration, and which can be thrown out with considerable force by the contraction of the body. The figures 1 and 6, *Lign.* 102, are views of a naked (that is, *shell-less*) cephalopod, showing the arms, eyes, and a pair of fins, for swimming. The Cephalopoda, thus endowed with powerful organs of locomotion, traverse the seas unrestricted, and are seen in groups of myriads in the midst of the ocean, and only appear periodically near the shores. Their fossil remains consist of—

1st. The external and internal shells, which are generally symmetrical, and either straight (as in *Orthoceras*, *Lign.* 106.); arched or bent (as in *Crioceras*, *Lign.* 109.); spiral (as in *Turrilites*, *Lign.* 112.); or, elegantly involute,* and simple (as in the *Argonaut*, and *Bellerophon*, *Lign.* 104.); or divided by smooth, or foliaceous partitions, into chambers or air-cells, connected by a hydraulic tube or siphuncle (as in *Nautilus*, *Lign.* 105, and *Ammonites*, *Lign.* 107.).

2dly. The internal horny or calcareous support, called *osselet*, and its appendages.†

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* *Involute*, as applied to the shells of Cephalopoda, implies that the inner whorls are embraced by the outer turn or whorl; *convolute*, the inner turns apparent, or exposed; *evolute*, the whorls coiled in one plane, but not touching each other; *revolute*, the extremities bent inwards.

† The *bone* or *shell* of the Cuttle-fish, the friable part of which, reduced to powder, forms *pounce*, is the *osselet* of that cephalopod.

3dly. The ink-bladder, with its inspissated contents, termed *sepia*.

4thly. The mandibles of the mouth or beaks (*Lign.* 105.).

5thly. The soft parts of the animal in the state of molluskite; impressions of the head and tentacula, and remains of the clasps or curved hooks of the arms of some species (see *Lign.* 100.).

These several parts are generally found separately, but they sometimes occur in their proper relative position, and from such examples the nature of the originals may be determined.

The Cephalopoda are divided by Professer Owen, into two orders, according to the number of their organs of respiration, or gills; namely, the *Dibranchiata*, or those which have two gills, called also *Acetabulifera*, from their arms being furnished with rows of little cups or suckers; and the *Tetrabranchiata*, which have four gills or branchiæ.

## FOSSIL DIBRANCHIATE CEPHALOPODA.

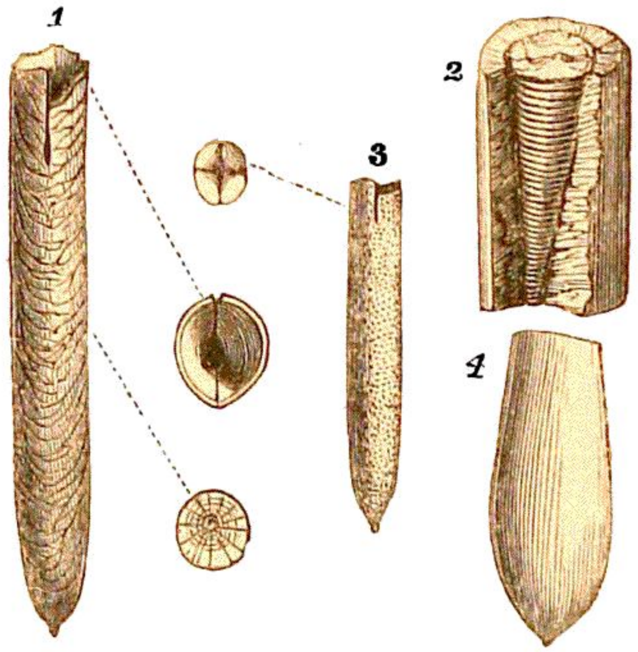
The *Argonaut*, or Paper Nautilus, whose elegant fragile shell is too well known to require description, is the only living genus of this order, in which the animal is protected by a hard calcareous external covering. This shell is symmetrical, and convoluted on a vertical plane, and consists of but one cavity or chamber. The other genera are naked, and possess an internal chambered shell (as in the recent *Spirula*), or some modification of such an apparatus. The last chamber or cell of these enclosed shells is too small to admit any part of the body of the animal; a character by which the fossil species may be distinguished from those of the other order. Others have a horny or calcareous osselet, as the bone of the Cuttle-fish, and pen of the Calamary or Sea-pen (see *Bd.* pl. 28.); and in an appendage of this kind, a conical chambered shell is contained in many of the fossil genera, hereafter to be noticed. These animals have eight arms, with the addition in some genera of two long tentacula, which are furnished with rows of suctorial disks or cups, called *acetabula* (see *Lign.* 102, figs. 1, 6.).

These naked Cephalopoda, devoid of any external defence, possess a very extraordinary means of escape from their enemies. They are furnished with a bag or bladder, containing a dark fluid resembling ink in appearance, which they have the power of ejecting into the surrounding water upon the approach of danger; and by the obscurity thus induced, foil the pursuit of their adversaries. The Nautilus and other cephalopods, protected by a large external shell, are destitute of such an apparatus; the co-existence of an ink-bag with the organization of the naked animals of this class, and its absence in those with outer shells, were pointed out by Professor Owen, more than twelve years ago, as an important element in the investigation of fossil Cephalopoda; one of those brilliant anticipations of the relations of structure in extinct organisms, with which this eminent philosopher has enriched the science of Palæontology, and which recent discoveries have fully confirmed. The deep brown colour, *sepia*, and the darker pigment, *Indian ink*, are the prepared fluid of the ink-bags of different species of Cuttle fish; a similar substance secreted by extinct naked Cephalopoda, as we shall presently demonstrate, is found in a fossil state. These preliminary remarks on the organization of the recent animals will prepare us for the investigation of the extinct species. We will first notice those remarkable fossils, called *Belemnites*, or thunder-stones.

BELEMNITE (from a supposed resemblance to the head of a dart or javelin). *Lign.* 101, 102, 103.—Among the innumerable relics of an earlier world, which swarm in the sedimentary deposits, there are perhaps no fossil bodies that have excited more curiosity, and given rise to so many fruitless conjectures as to their nature and origin, as the Belemnites.* These are long, cylindrical, or fusiform stones, more or less pointed at one extremity, and having at the other, and larger end, a conical cavity, which is either occupied by a chambered shell, or filled up with the material in which the fossils were imbedded. The substance of these stones is calcareous spar, varying in colour from a

* See Org. Rem. Vol. III. p. 122.

dark brown to a light amber; many species are transparent, others nearly opaque. When broken transversely they present a radiated structure (*Lign.* 101, fig. 1.); and a minute central cavity, or axis, is




LIGN. 101. BELEMNITES: $\frac{1}{3}$ *nat.* *Cret. and Oolite.*

Fig. 1.—BELEMNITELLA MUCRONATA. *Chalk. Brighton.* On the right of the figure is a view of the aperture, and a transverse section.

2.—Portion of a Belemnite, containing the internal conical chambered shell, called *phragmocone*. *Oolite.* (*By Sir Woodbine Parish.*)

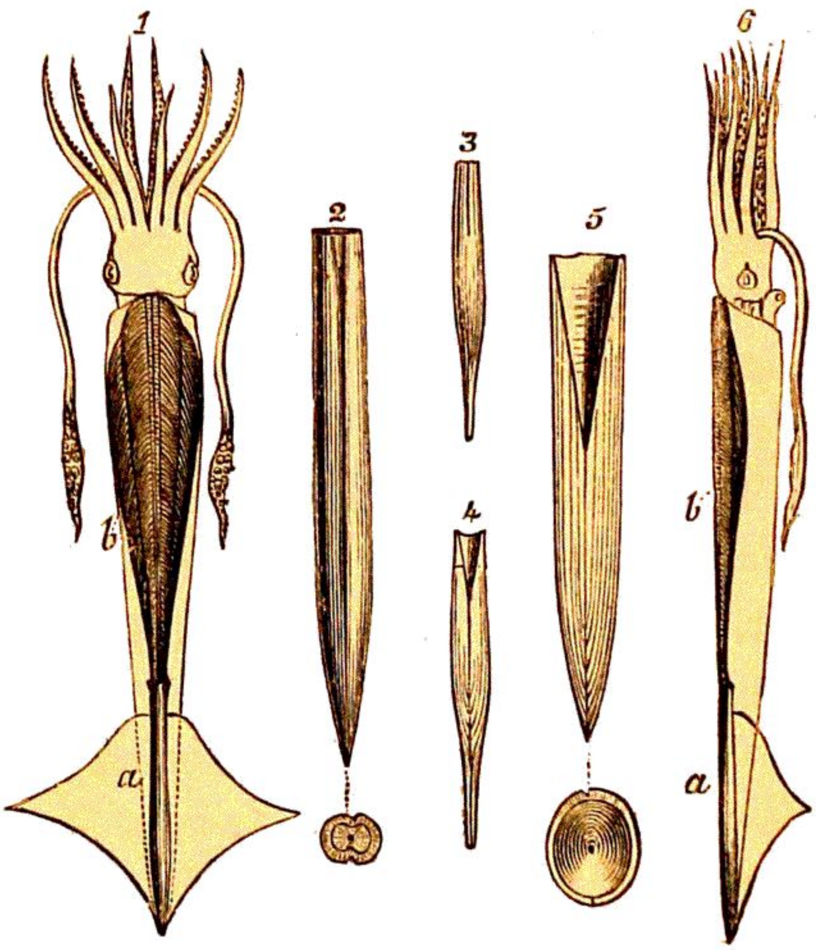
3.—BELEMNITELLA QUADRATA. *Beauvais, France.* The quadrangular cavity is shown in the upper figure on the left. (*M. D'Orbigny.*)

4.—BELEMNITES DILATATUS. *Lower Green Sand* (*Néocomien*). *France.*

seen to extend through the whole length of the solid portion of the stone (see *Lign.* 102, fig. 5.). A longitudinal section (*Lign.* 102, figs. 4 and 5.) shows the conical cavity in the upper part, and that the shaft consists of a series of successive concentric layers.

Such are the usual characters of these fossils in the examples of most frequent occurrence. They vary in size from the small, delicate, transparent, species, *Lign.* 102, figs. 3 and 4, to massy opaque specimens, several inches in circumference, and ten or twelve inches in length. They present also considerable variety of form; some are regularly cylindrical, as the chalk species, *Lign.* 101, fig. 1; others broad and flattened, as fig. 4; others subfusiform, as *Lign.* 102, figs. 3 and 4. The small end is slender and pointed in some belemnites, and in others is obtuse, or rounded, with an abrupt projecting point. In general there is a longitudinal groove, or furrow; and some species have a furrow on each side (see *Lign.* 102, fig. 2.).

But the fossils above described are only a part of the original structure of the Belemnite. When in a perfect state, the cavity seen in *Lign.* 102, fig. 5, is occupied by a chambered conical shell, called the *phragmocone*, composed of a series of shallow concave cells, of a nacreous or pearly substance, pierced by a siphuncle, which is situated at the margin: see *Lign.* 101, fig. 2 (*Bd.* pl. 44, fig. 17 *b.*). This conical chambered shell is enveloped in a sheath of opaque calcareous matter, which passes upwards into a thin, horny, laminated case, or receptacle, that contained the ink-bag, and other viscera: see *Lign.* 103 (*Bd.* pl. 44, fig. 7 *b.*).




LIGN. 102. BELEMNITES: ½ *nat.*

Fig. 1.—A front view of the supposed animal of the Belemnite, by *M. D'Orbigny*. *b.* denotes the osselet, to the base of which the Belemnite, *a*, is attached.

2.—BELEMNITES BIPARTITUS; the figure below shows the form of the aperture. *Neocomian Formation. France.* (*M. D'Orbigny.*)

3.—BELEMNITES LISTERI (G. A. M.); *from the Galt. Ringmer.*

4.—A longitudinal section of B. LISTERI.

5.—BELEMNITES SEMICANILICULATUS: a longitudinal section; the figure below is the aperture of the *alveolus*. *From the Firestone* (*Craie tufeau*) *of France.*

6.—A side view of fig. 1.

The BELEMNITE therefore consists of—

1st. The spathose osselet, or *guard*, as it is termed, which is formed of calcareous spar of a radiated structure, having at the larger end a conical cavity, called the *alveolus*, as in *Lign.* 101, fig. 1, and *Lign.* 102, fig. 5.

2dly. A conical chambered, pearly shell, termed the *phragmocone*, which is situated in the alveolus, as in *Lign.* 101, fig. 2.

3dly. The horny prolongation of the *phragmocone*, for the reception of the ink-bag, called the *receptacle*, as in *Lign.* 103, *a*, *a* (*Bd.* pl. 44, figs. 10—13.).

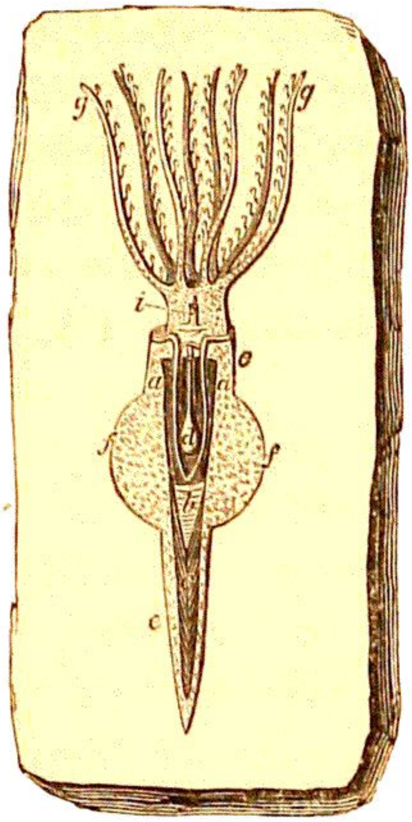
4thly. The *ink-bag*, and its inspissated fluid, *sepia*; *Lign.* 103, *d* (*Bd.* pl. 44, figs. 7, 9.).

The invariable radiated crystalline structure of the Belemnite has evidently resulted from the peculiar organization of the original osselet.

From the obvious analogy of the structure above demonstrated, with that of the recent dibranchiate Cephalopoda, several eminent naturalists inferred that the animal of the Belemnite was closely related to the existing types; and the late Mr. Miller, in a communication to the Geological Society of London, gave a restored figure of the original, which, as modified by M. D'Orbigny, is represented *Lign.* 102, figs. 1 and 6. The indefatigable and successful researches of the Rev. Dr. Buckland have confirmed the general correctness of this restoration. In the Lias of Devonshire several specimens of the Belemnite, with its chambered shell, and horny or pearly receptacle, containing the ink-bag and its contents, have been discovered. (*Bd.* pl. 44′, 44″.) The name of BELEMNO-SEPIA is given by Dr. Buckland to the original animal, to indicate its character and relations. But more recently, an unexpected light has been shed upon the nature of these extinct Cephalopoda by the discovery in the Oxford clay of the Oolite, near Chippenham, not only of several examples, with the osselet, receptacle, and ink-bag, in their natural relative positions, but also with the remains and impressions of the mantle, body, tentacula with their hooks or clasps, and the fins!

Certain argillaceous strata of the Oolite, as well as of the Lias, appear to have been peculiarly favourable for the preservation of the muscular tissue and integuments, for not only the soft parts of mollusca, but also the skin, and cartilaginous structures of the Ichthyosauri, and other reptiles, are often preserved; probably, as Professor Owen suggests, by their conversion into *adipocire*, and subsequent mineralization; and I have seen indications of the epidermis, and ligament of the hinge of fresh-water bivalve shells, in the clays of the Wealden.

In a specimen discovered by Mr. Pratt, "the large sessile eyes, the funnel, a great proportion of the muscular parts of the mantle, and the remains of the two lateral fins, the ink-bladder, and duct, and a considerable portion of the phragmocone




LIGN. 103. THE ANIMAL OF THE BELEMNO-SEPIA. *Oxford Clay. Chippenham;* discovered by the Marquess of Northampton, P.R.S.

(*From the Hunterian Lectures for* 1843, *by Professor Owen.*)

*a, a.* The soft body of the animal; the space between the letters is the *receptacle*, or horny expansion of the *osselet*.

*b.* The conical chambered shell, or *phragmocone*, in the *alveolus* of the osselet, or guard of the Belemnite.

*c.* The guard, or *osselet*, which is commonly termed the *Belemnite*.

*d.* The ink-bag and its ducts, lodged in the cavity of the receptacle, or horny expansion of the osselet.

*e.* The collar of the body.

*f, f.* The fins.

*g, g.* The eight arms, or tentacula.

*i.* The external opening of the funnel, or siphon, by which the water is ejected in respiration, and for locomotion.

remain."* The mandibles or beaks of the Belemnite are supposed to have been horny, as in the other naked Cephalopoda; since no calcareous beaks have been found associated with their remains. "The arms were eight in number, and provided not with simple acetabula, but with a double alternate series of slender elongated horny hooks, as in the genus of existing Calamaries, called *Onychoteuthis*"† (*hook-calamary*).

In the position of the fins the Belemnite resembled the *Sepiola*, but in the structure of its internal shell it most nearly approached the Sepia, or Cuttle-fish; while in its armed tentacula, it was related to the Onychoteuthis. "The Belemnite, having the advantage of its dense, but well-balanced internal shell, must have exercised the power of swimming backwards and forwards, which it possessed in common with the modern decapod (*ten-armed*) Dibranchiata, with greater vigour and precision. Its position was probably more commonly vertical than in its recent congeners. It would rise swiftly and stealthily to infix its claws in the belly of a supernatant fish, and then perhaps as swiftly dart down, and drag its prey to the bottom and

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* Lectures on the Comparative Anatomy and Physiology of the Invertebrate Animals, delivered at the College of Surgeons, in 1843; by Richard Owen, F.R.S., Hunterian Professor, &c. 1 vol. 8vo.

† Oper. cit. p. 338.

devour it. We cannot doubt at least but that, like the hooked Calamaries of the present seas, the ancient Belemnites were the most formidable and predaceous of their class."*

In the cream-coloured limestone of Solenhofen, so rich in organic remains of the highest interest (*Wond.* p. 450.), the soft parts of naked Cephalopoda have also been discovered. I have figured, *Lign.* 100,† a beautiful specimen obtained by the late Count Munster, which exhibits the sharp imprint of the head and body, with the hooks of the tentacula. M. D'Orbigny supposes that the original animal closely resembled a recent decapod called *Enoploteuthis leptura.* The internal osselet was straight, and terminated in a point.

The fossils which have afforded this unexpected and highly interesting illustration of the nature of the extinct animals of the Belemnites, have been obtained by searching for these remains in the strata in which they abound, and before removing the solid osselet, or Belemnite commonly so called, carefully examining the surrounding stone for traces of the more perishable parts. But for this precaution of the noble President of the Royal Society, the specimen, *Lign.* 103, would have only yielded a common Belemnite. The attention of the collector can scarcely be too often directed to the necessity of

* Hunterian Lectures, p. 339.

† From *Paléontologie Française.*

examining the surrounding matrix before extricating a fossil from its bed.

The Belemnites of the oolitic limestones, frequently contain the phragmocone, either transmuted into calcareous spar, or retaining its original shelly structure. In the clays the horny sheath or receptacle is sometimes found pressed flat, and extending above the alveolus of the osselet, and has often a thin coat of nacre of a pearly lustre; but it is more commonly detached, and the *ink-bag*, and its inspissated contents, the sepia, enclosed within. The ink-bag and its tube or duct, but little compressed, are occasionally met with, having a brilliant nacreous pellicle, the remains of the sheath, attached to the surface. The ink-bag is occasionally of considerable magnitude; specimens have been found at Lyme Regis, nearly a foot in length.* The circumstance of the ink-bags being generally full of sepia, admits of the inference (as Dr. Buckland with his wonted acumen remarks), that they died suddenly; for their living analogues eject the inky fluid, upon the least approach of danger. The perfect condition of the bag, proves also their instant enclosure in the deposit, for the distended membrane would otherwise have burst from decomposition, and the contents have escaped. The fossil marine reptiles, the Ichthyosauri, &c., with which

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* See Bd. Vol. I. p. 372—379.

these Belemnites are associated, present similar phenomena, as we shall hereafter have occasion to remark, and strengthen the probability that swarms of the inhabitants of the Liassic ocean were suddenly destroyed, and imbedded, on the areas now occupied by their remains.

The Belemnites abound in the Lias, Oolite, and Chalk, and have not been discovered in England, in any other deposits; there are nearly thirty British species, some of which are restricted to the Chalk, and others to the Oolite and Lias.

A few characteristic forms are represented, *Lign.* 101, and 102, in order to illustrate the three groups, which according to M. D'Orbigny are peculiar to the grand divisions of the Cretaceous formation.

1. BELEMNITELLA MUCRONATA. *Lign.* 101, fig. 1.—The name *Belemnitella*, is given to those Belemnites which have a slit, or crevice, on the anterior margin of the alveolus, or cavity, and two lateral impressions. The surface is sometimes granulated, and often has vascular markings, produced by the investing integument of the living animal. The form of the aperture is shown in the middle dextral figure; and the radiated structure, as seen by a transverse section, in the sketch below. Professor Owen remarks, that a microscopical examination proves the spathose aggregation of subtransparent calcareous matter, forming the guard, to be the effect of original formation, and not of infiltration

of a mineral substance into an originally porous texture; but my own observations lead me to consider this question as *sub judice;* for we have yet much to learn as to the nature of those transmutations, which organic bodies undergo in the mineral kingdom. This species is abundant in the *White Chalk*, particularly in certain localities in Norfolk and Devonshire. It is more frequent in the chalk of Kent than in that of Sussex; and in the cretaceous strata around Brighton, than in those near Lewes. I have never been able to detect the least vestige of a phragmocone, or chambered shell, in the alveolus. This Belemnite is occasionally imbedded in flint nodules; and such examples possess the calcareous crystalline structure of the chalk and limestone specimens. In the chalk of Ireland, the Belemnites which have been corroded, or perforated by the depredations of some marine borers, are often injected with flint; and if the calcareous substance be removed by immersion in dilute hydrochloric acid, exquisite siliceous casts may be obtained. It is not unusual to find flints with a cavity, occasioned by the solution and removal of the calcareous guard, and having a siliceous conical cast of the alveolus, occupying the upper part of the interspace. The reader will recollect that the pulley-stones of the Derbyshire Encrinites were produced by a similar process (see p. 317.).

The American cretaceous sands abound in a species of Belemnitella, nearly related to *B. mucronata.*

2. BELEMNITES LISTERI. *Lign.* 102, fig. 3.—This small, elegant Belemnite has two lateral grooves, and is generally as transparent as amber; it has frequently a nacreous or calcareous pellicle partially investing the guard. It seldom exceeds two inches in length. It is abundant in, and peculiar to, the GALT, or blue marl of the Chalk, and is constantly associated with the Inocerami, previously described as common at Folkstone, Bletchingly, Ringmer, and other localities of that deposit. The Red Chalk of Norfolk, and the Speeton Clay of Yorkshire, contain the same, or a closely allied, species (*Min. Conch.* tab. 589.).

3. BELEMNITES DILATATUS. *Lign.* 101, fig. 4.—This species is distinguished by its flattened form, and by the siphon of the phragmocone being situated on the margin opposite to the longitudinal furrow, instead of being on the same side, as is most usual. It is supposed by M. D'Orbigny to be characteristic of the lowermost division of the Shanklin Sand.

The Chalk-marl contains a Belemnite of a more elongated form than those above described, the apex gradually tapering to a point, with a slight double furrow on each side. It is named *B. lanceolatus* (*Sow. Min. Conch.* tab. 600, figs. 8, 9.), and is very common in the marl-pits at Steyning, Clayton, and Hamsey, in Sussex.

At the base of Golden Cap Hill, near Charmouth, there are two strata of marl observable on the shore, which are literally paved with Belemnites. Great numbers of these fossils have Serpulæ, and other extraneous shells, attached to them; a proof that the ink-bags, and other soft parts of the mollusks, had decomposed, and that the guards had lain uncovered at the bottom of the sea.*

Beloptera (*Bd.* pl. 44, fig. 15. *Min. Conch.* tab. 591.).—Under this name Mr. Sowerby figures and describes a very curious fossil, from the London Clay at Highgate, which seems to hold an intermediate place between the Cuttle-fish and the Belemno-sepia. The guard, which is of an oblong form, with an obtuse apex, has the structure of the osselet of the sepia, and contains in its upper part, a phragmocone, the cells of which are very narrow. In strata of the same age, in France, three species have been discovered by M. Deshayes. I allude to these shells, that the attention of the collector may be directed to the search after other examples in our tertiary deposits.

Fossil Calamary, or Squid (*Bd.* pl. 28, 29.).—The common Calamary (*Loligo vulgaris*) is so often seen on our shores, that its general aspect must be familiar to all who frequent the sea-side. In this

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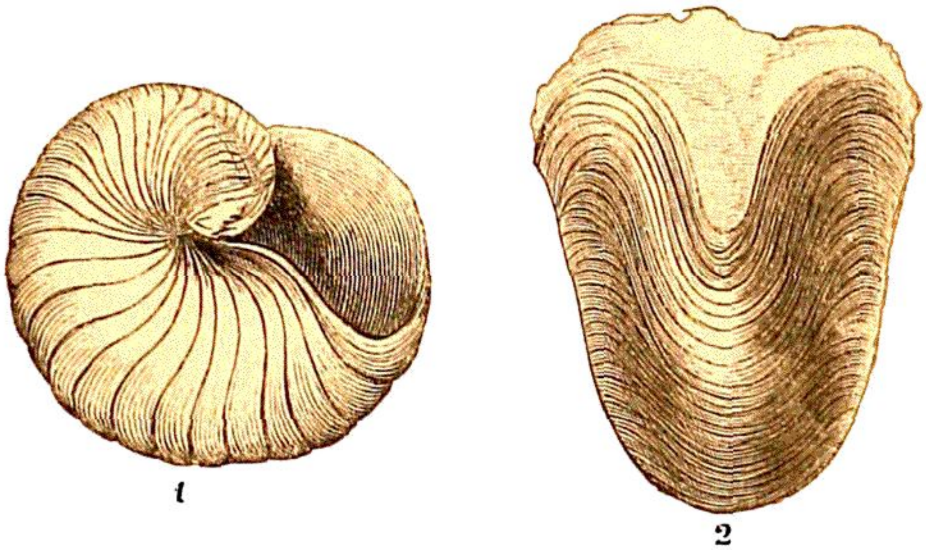
* Bd. p. 377. This work should also be consulted for more detailed information relating to the Belemnites, and other fossil Cephalopoda.

animal, the osselet, or internal support, is a cartilaginous elongated body, which, from its form, is called Sea-pen (*Bd.* pl. 28); and even this delicate structure is found in a fossil state. In the Lias of Lyme Regis, Miss Mary Anning first discovered specimens of *Sea-pens*, in juxtaposition with the ink-bag, as in the recent Calamary; and subsequently many similar examples have been found, both in Englan and on the continent. Dr. Buckland has given some exquisite figures of these fossils; and his collection contains a matchless series of these most interesting organic remains.



LIGN. 104. FOSSIL SHELLS RELATED TO THE ARGONAUT.

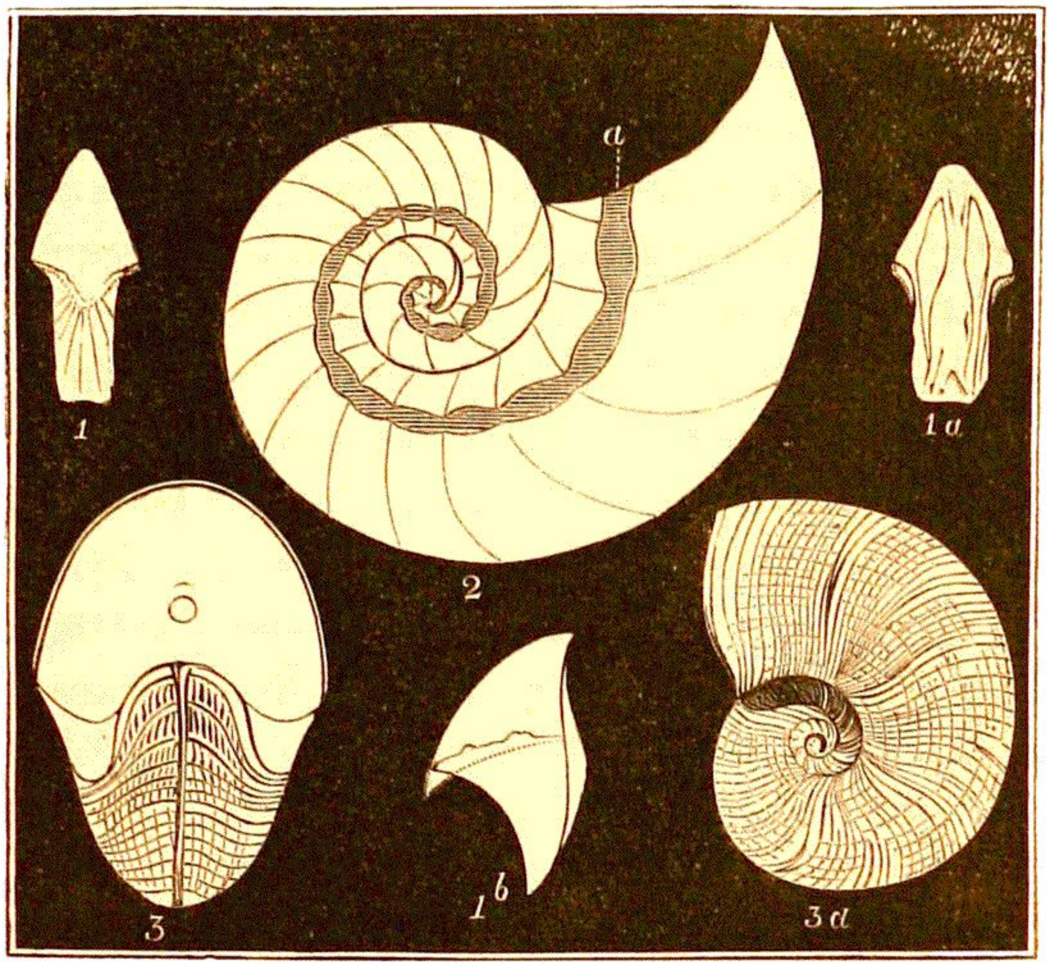
Fig. 1.—BELLEROPHON COSTATUS. *Mt. Limestone. Yorkshire.*
2.—BELLEROPHON BILOBATUS. *Sil. Syst.*

It has been already stated, that the animals of one genus of the existing dibranchiate Cephalopoda are protected by a thin, flexible, symmetrical keeled shell, convoluted on a vertical plane, and having but one chamber—this is the *Argonaut*, or *Paper Nautilus*, an inhabitant of the Mediterranean. This animal belongs to the Octopoda, or those which have eight arms; and in one pair of these processes the extremities expand into broad and thin membranes, by which the delicate, elastic, calcareous envelopement, or shell, is secreted. These membranes usually encompass the shell, and meet and overlap each other along its keel; and by them the shell is chiefly retained in its position. When these membranes are withdrawn, or the animal dies, the shell, having no muscular connexion with the soft parts, readily separates from the body. Hence the doubts so long entertained as to the relation between the animal of the Argonaut and its shell, but which are now set at rest; the anatomical structure, so admirably demonstrated by Professor Owen, having removed the obscurity in which the subject was formerly involved.

In the Silurian, Devonian, and Carboniferous deposits, there are several species of a genus of shells, the animals of which are considered to have been analogous to the recent Argonaut. It is named BELLEROPHON. I have figured two species; one from the Mountain Limestone, *Lign.* 104, fig. 1; the other from the Silurian System. There are about thirty British species, most of which are of small size; some of them are keeled, others have a slight dorsal depression, as in fig. 1, and many have the back rounded, and the sides lobed, as in *Lign.* 104, fig. 2.

## FOSSIL TETRABRANCHIATE CEPHALOPODA.

I am not aware of any British fossils referable to the internal *discoidal* chambered shells, peculiar to




LIGN. 105. FOSSIL NAUTILI. *Chalk-marl.*

Fig. 1.—BEAK OF A NAUTILUS.
1a.—Posterior view of the same.
1b —Profile of the beaks of a Nautilus.
2.—Vertical section of NAUTILUS PSEUDO-ELEGANS. *Hamsey.*
*a.* The siphuncle.
3.—Front view of N. DESLONGCHAMPSII. (*M. D'Orbigny.*) *Hamsey.*
3a.—Lateral view of the same.

the dibranchiata; for the minute fossil polythalamia, formerly referred to this class, are now known to have belonged to animals possessing an organization altogether different, as we have elsewhere explained (see page 232.). I therefore proceed to notice the fossil remains of those *Cephalopoda*, which were furnished with an external shell, having its cavity divided by cells, perforated by a hydraulic tube or siphon; and of which the recent NAUTILUS is the type.

The appearance and structure of the recent shell are familiar to every one; a correct knowledge of the nature of the original animal has, however, been obtained but very recently. In its general characters the animal of the Nautilus, which is an inhabitant of the seas of hot climates, resembles the naked Cephalopoda: it possesses four *branchiæ*, or gills, and numerous hollow arms and retractile tentacula. Its head is furnished with a muscular flattened disk, which serves as an operculum to the shell when the animal is retracted, and as an organ for creeping when on the ground. The beaks are horny, and coated at their tips by calcareous matter. It has no ink-bag, and is destitute of fins or other organs for swimming. The body occupies the ample outer cell of the shell, to which it is firmly attached by two lateral muscles; and it has a contractile siphunculus, that passes from the posterior part of the animal through the shelly tube, and by which communication is maintained with the entire series of cells or chambers.*

* The reader interested in this subject should consult the highly philosophical "*Memoir on the Pearly Nautilus*," by

Upon making a vertical section of the shell, the inner volutions are exposed, and the cavity is seen divided at regular intervals into cells, by smooth, slightly undulating, nacreous septa; these vary in number according to the age of the individual; there are about thirty-five in an adult specimen. The partitions are pierced in the *centre* by a shelly tube which traverses each cell, to within a short distance of the next partition; and this tube is rendered a continuous channel in the living animal, by the membranous siphuncle. This series of air-chambers constitutes an apparatus which renders the Nautilus nearly of the same specific gravity as the surrounding water, and enables it to rise to the surface of the sea, or sink to the bottom, simply by altering the extent of the surface exposed to the water by its soft parts.

From this very general description of the only living representative of the numerous genera of tetrabranchiate Cephalopoda, which swarmed in such prodigious numbers in the ancient seas, we may pass to the consideration of the fossil Nautili, and their related congeners. Our remarks must be limited to the genera that will serve to demonstrate the most important modifications of structure, and explain the nature of the fossil remains of this extensive class of extinct beings.

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Professor Owen; 1 vol. 4to. 8 plates. 1832; or the Article CEPHALOPODA; *Cycloped. Anat.* by the same distinguished zoologist.

The genera into which these shells are distributed are founded upon the form, and mode in which the shell is coiled; the character of the partitions or septa, and the situation of the siphuncle. A little reflection will enable the student to understand the principles of this classification. The essential character of all the shells of this class, is to have an external chamber larger than the inner, and which contains the body of the animal; to be divided internally into different compartments, by partitions; and to have a pipe or tube extending from the outer open chamber to the innermost cell. They are divided into two groups or families.

1. The Nautilidæ (*Bd.* plate 31.): in these the septa are smooth, or but slightly undulated, and the siphon is either in the centre of the disk of the cells, or situated towards the inner margin or turn of the spire.

2. The Ammonidæ (*Bd.* plates 35—42.): in these the septa are more or less waved, and their margins foliated or crenated, that is, indented; and the siphon is situated either on the margin or towards the back.

Of the Nautilidæ three genera require our attention, namely, *Nautilus*, properly so called; *Orthoceras* (*straight-horn*), in which the shell, instead of being involuted or coiled up, is straight; and *Cyrtoceras* (*curved-horn*), which may be described as an orthoceras gently curved.

In the NAUTILUS, the shell is convoluted on the same plane, in spiral whorls, all of which are contiguous, and the siphon central.

The British strata contain about sixty species of *Nautili*. The Tertiary formations have yielded five or six; the Cretaceous a like number; the Lias and Oolite ten or eleven; the Carboniferous about thirty species; and the Devonian two species. I believe no trace of the genus has been observed in strata of earlier formation; although the straight and curved *Nautilidæ*, the *Orthoceras*, and *Cyrtoceras*, abound in the Silurian and Devonian systems. In the London Clay a large and beautiful species is abundant (*Nautilus imperialis*. *Min. Conch.* tab. 1.), having the shell very commonly entire; but the outer opaque coat frequently flakes off, and exposes the pearly or nacreous internal layer. The septa generally retain their original nacreous structure, and the cells are either occupied by clay or marl; or partially filled or lined with calcareous spar, brilliant pyrites, or other mineral matter. These Nautili are often found constituting the nuclei of the *septaria*, or clay nodules, with which this deposit abounds.

A small species (*N. centralis*. *Ly.* I. p. 341.), occurs in the same strata. The Isle of Sheppey, and the London Clay, on the coasts of Hants and Sussex, are productive of these fossils. In the White Chalk near Lewes, casts of several very large Nautili have been found; but shells of this genus are more abundant in the lower division, the *Chalk-marl.* A large and beautiful species, *Nautilus elegans* (*Min. Conch.* tab. 116.), is not unusual in the marl-pits near Lewes, Clayton, Steyning, &c. and may be considered as characteristic of that portion of the Cretaceous deposits. The first specimen discovered was from (*Foss. South D.* Tab. XX.) the marl-bank immediately at the foot of the mound on which stands the church of HAMSEY, a little hamlet on the north of Lewes; a spot from which I obtained numerous other cephalopodous shells, at that time unknown as British species. The collocation of fossils at Hamsey, is similar to that observable in the quarries at St. Catherine's Mount, near Rouen. These remains only occur as casts, no vestige of the shell remaining; but sections will sometimes show the situation of the siphon, its tube being filled with a different material from that which occupies the cells. This is exemplified in the section of a smaller species (*N. pseudo-elegans, Lign.* 105. fig. 2.), in which the channel of the siphon is filled with a dark-coloured marl, *a*; the lines formed by the section of the smooth septa are also shown. In the same lignograph, fig. 3, a front view and profile of another marl Nautilite is figured.*

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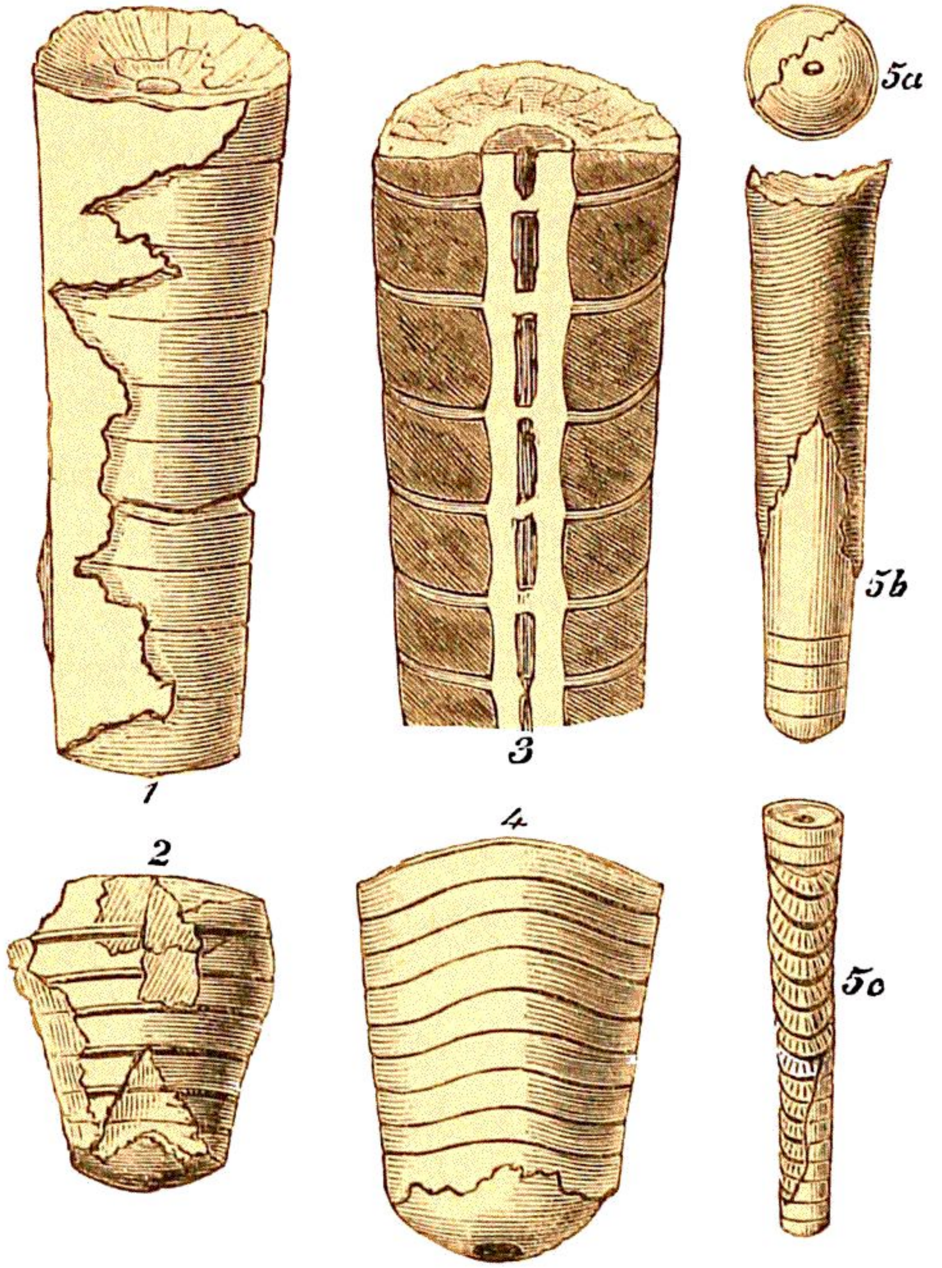
* The student will find a section of the shell of the recent Nautilus a very instructive object of comparison, in the investigation of the fossils of this family.

In the Chalk, as well as in many other calcareous deposits, the shells of the Nautili, Ammonites, &c. are very rarely preserved; even the internal septa are dissolved, and the stony casts moulded in the cells, very often remain distinct, and readily separate. An entire series, from the innermost cell to the outer chamber, may sometimes be obtained; forming, as it were, a dissected model of the internal structure.* The beaks or mandibles are occasionally found fossil (*Lign.* 105, fig. 1.).

The ORTHOCERAS, *Lign.* 106.—The shells of this genus may be described as Nautili uncoiled, and extended in a straight line. They are straight, elongated, chambered shells, with smooth and gently undulated septa, concave towards the opening or upper part, and having the siphon central, or not far removed from the centre. It is supposed that the small extremity is bent or curved in some species. The *Orthoceratites* more especially belong to the ancient Secondary strata. They first appear in the Carboniferous, and abound in the Devonian and Silurian. They vary in size from a few inches to several feet in length, and eight or nine inches in diameter; and in form, from a slender elongated cone, to a short, massy, almost cordiform figure, with a nearly circular base. Some examples

* Bd. pl. 42, fig. 1: see also plates 31 to 43, for illustrations of Nautilites.




LIGN. 106. ORTHOCERATITES.

Fig. 1.—ORTHOCERAS STRIATUM. (*Min. Conch.*) *Devon.*

2.—ORTHOCERAS CONICUM. *Whitby. Carb.*

3.—Vertical section of an *Orthoceras*, showing the central siphon, and the chambers. *Devonshire.*

4.—ORTHOCERAS LATERALE. *Carb.* (*Min. Conch.*)

5.—ORTHOCERAS GREGARIUM. (*Murch. Sil. Syst.*)

*a.* One of the septa.

*b.* A portion covered at the upper part by the shell.

*c.* The lower part of the same specimen, displaying the septa.

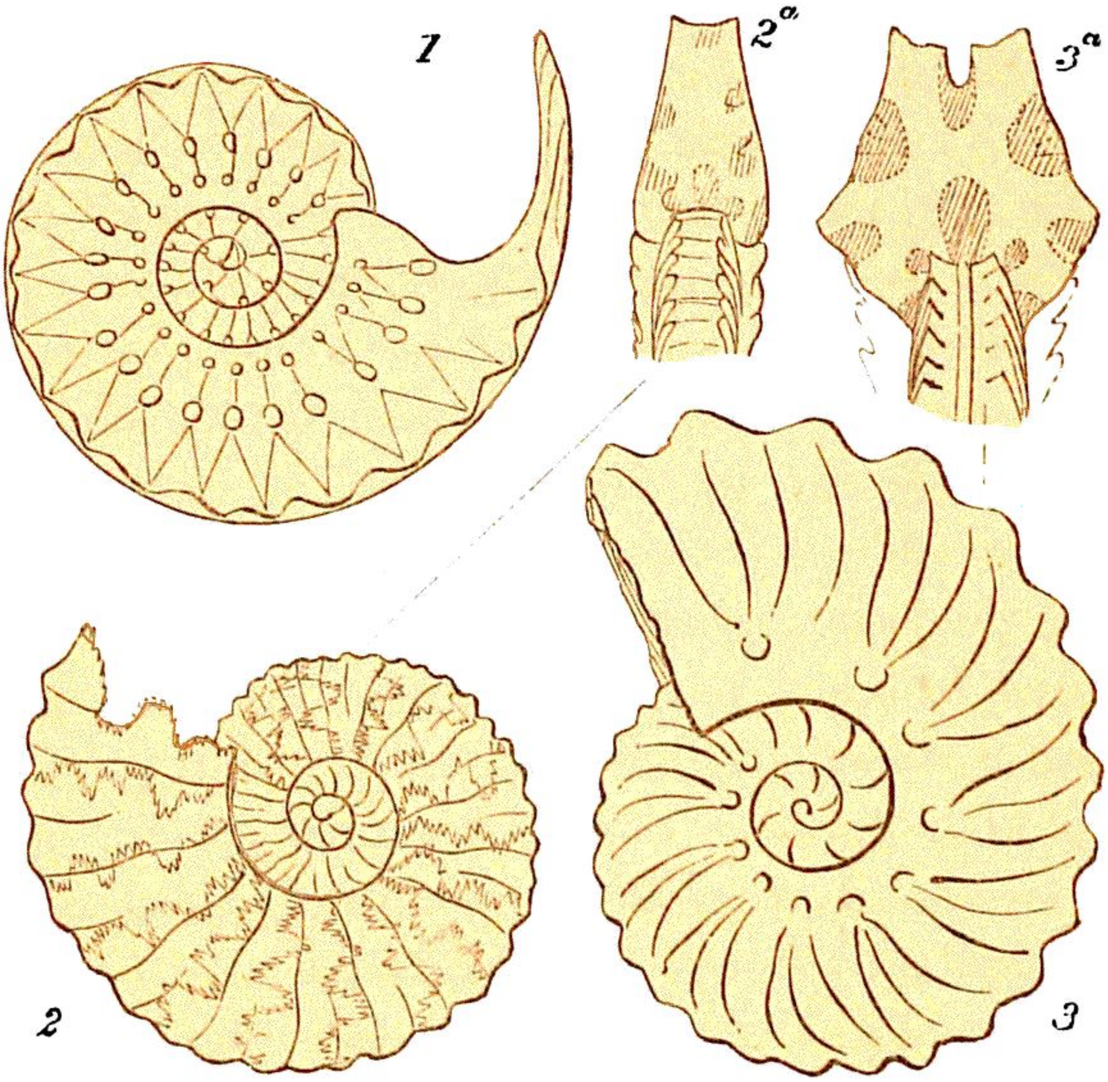
have been noticed with upwards of sixty cells. Mr. Sowerby figures and describes *O. giganteum* (*Min. Conch.* tab. 246.), from Scotland, as exceeding seven or eight feet in length; and I discovered on the beach at Brighton, where it had probably been brought by some vessel, among ballast, a fine fragment of the same species, indicating as great a magnitude. Several species are figured, *Lign.* 106, to show the structure and appearance of these fossils. The casts of the separate cells are often found. The section, fig. 3, from the red marble of Devonshire, beautifully displays the situation of the siphunculus and the lines of the septa. The shelly siphon, which is moniliform (*bead-like*) or dilated, at each chamber, is replaced by white spar; and the membranous internal tube is filled with a dark substance, probably molluskite.

There are some species in which the internal tube is calcareous, as well as the external one, and the two are connected at regular intervals, by radiating, hollow processes (see *Ly.* II. p. 175.). These Orthoceratites have been principally obtained from the Silurian limestones, at Lake Huron; they also occur in Ireland. Mr. Stokes, who first investigated their structure, has arranged them in a distinct genus, with the name of *Actinoceras* (*radiating-horn*).*

Slabs of reddish limestone, containing Orthoceratites, may be seen in some of the pavements at

* See Geol. Trans. Vol. V. p. 708.

Hampton Court, and in Chelsea College, which when wet present excellect sections of the enclosed shells.




LIGN. 107. AMMONITES FROM THE CRETACEOUS FORMATION.

Fig. 1.—AMMONITES VARIANS. *Chalk-marl, Hamsey.*
2.—AMMONITES DUFRENOYI.
2 a.—Shows the keel and septum of the same.
3.—AMMONITES LAUTUS. *Galt, Folkstone.*
3 a.—Keel and septum of the same.

AMMONITIDÆ. — The AMMONITES, or *Cornua Ammonis*, (so called from a supposed resemblance to the horns engraven on the heads of Jupiter Ammon,) are among the most common and well-known fossils of the British secondary strata. In some districts, as in Yorkshire and Somersetshire, where the Ammonites abundantly prevail, they were noticed in very remote times. Local legends, ascribing their origin to swarms of snakes turned into stone by the prayers of some patron saint, are still extant, and perpetuated by the name of *snake-stones*, by which these fossils are provincially known. The Lias, near Whitby, in Yorkshire, contains immense numbers of two or three small species, one of which is figured *Lign.* 91, fig. 7.

The shells comprehended in this family are either spiral, involute, arched, or straight; their septa are deeply lobed, and have the margins foliated. The siphon is dorsal, as shown by the notch in the cast, *Lign.* 107, fig. 3 [a]. Several hundred species have been described; they are divided into genera, which are characterized by essential modifications in the direction of the spire, and the inflections of the septa. Thus, in the *Ammonites*, *Lign.* 107, the spire is involute, and all the turns contiguous; in *Crioceras* (*curved-horn*) *Lign.* 109, fig. 2, evolute; in *Scaphites*, incurved at both extremities, *Lign.* 111; *Hamites*, siphonous, or hooked, *Lign.* 110, fig. 1; *Turrilites*, spiral, round an axis, *Lign.* 112; and in *Baculites*, straight, *Lign.* 110, fig. 2. New genera are continually being added, to embrace modifications of structure which appear to be too important for specific distinctions. I will endeavour to render this arrangement more clear to the student by the following definitions.

A straight tube, or horn, of an elongated conical figure, tapering to a point, and having its cavity divided by transverse partitions, which septa are not straight, but undulated, and their edges, which fit into the walls of the tube, deeply wrinkled, and the whole series pierced by a pipe running along near the outer margin, would be the model of the shell termed *Baculite*, *Lign.* 110, fig. 2. (*Bd.* pl. 44, fig. 5.); which may be regarded as a straight Ammonite. A similar shell, gently arched or curved, would be a *Toxoceras*, *Lign.* 109, fig. 1; the same tube, bent upon itself, like a siphon, into unequal limbs, not contiguous, a *Hamite*, *Lign.* 110. (*Bd.* pl. 44, fig. 10.); bent and approximate, or anchylosed in a straight line, *Ptychoceras*, *Lign.* 110, fig. 4; partially convoluted, the whorls contiguous, and the free end recurved, *Scaphites*, *Lign.* 111; the same form, but the spire not contiguous, *Ancyloceras*, *Lign.* 109, fig. 3; spirally twisted around an axis, *Turrilite*, *Lign.* 112. (*Bd.* pl. 44, fig. 14.); coiled, but the turns not touching each other, *Crioceras*, *Lign.* 109, fig. 2; lastly, coiled up in the form of a disk, all the turns being contiguous, AMMONITES.

AMMONITES. *Lign.* 107.—Shell discoidal, more or less compressed, whorls of the spire contiguous. and often visible; septa lobed, their margins deeply sinuated; aperture symmetrical, border or lip thickened, often notched and auriculated. Siphon dorsal.

The student will be able readily to distinguish Ammonites from Nautili by attention to the above definition. The situation of the siphon, the foliated or wrinkled edges of the septa, as shown in the cast, *Lign.* 107, fig. 2; and when these characters are wanting, the arched ribs and elevations, as in figs. 1 and 3, will serve as discriminating features. Like the fossil Nautili, the Ammonites most commonly occur as casts, the shell having been dissolved. Sometimes these consist of semi-transparent calcareous spar, the cast of each cell being distinct, but held together by the interlocking of the foliations of the septa; such examples are of great beauty and interest (see *Bd.* pl. 42, figs. 2, 3.); they most frequently occur in the limestones of the Oolite. The siphuncle is often preserved, even in the chalk specimens, in which all traces of the shell are lost. In a large Ammonite from near Lewes, not only the shelly siphuncle remains, but even the internal membranous tube, converted into dark molluskite. Separate portions of similar fossil siphuncles occur in the chalk, and have been mistaken for tubular shells.

The outer lip, or margin of the aperture, is occasionally found entire. In some species there is a dorsal process, as in a very common Chalk Ammonite (*A. varians*, *Lign.* 107, fig. 1.), which extends far beyond the margin; in other species, from the Oxford Clay, there are long, narrow, lateral appendages. An Ammonite is mentioned by Professor Owen, as having been discovered by Mr. Pratt in the same deposit, in which "the mouth of the shell is arched over transversely by a convex, calcareous plate, continued from the lateral margins of the outlet, and dividing it into two apertures; one corresponding with that above the hood of the Nautilus, which gives passage to the dorsal fold of the mantle; the other with that below the head, whence issue the tentacles, mouth, and funnel."

From the small size of the cells of the Ammonites, particularly in those species which are of a depressed or flattened form, it was long doubted whether the outer chamber could have been sufficiently capacious to contain the body of the animal; and it was supposed that these shells were internal, like the recent *Spirula*, or *Crosier*. But Dr. Buckland has clearly demonstrated, that the outer cell of the Ammonite, if restricted in breadth, is sufficiently ample in length to have contained the soft parts of a Cephalopod, equal in magnitude to the largest known specimens, its proportion to the chambered part being as considerable as in the Nautilus. The outer chamber often occupies more than half, and in some instances the entire circumference of the outer whorl (see *Bd.* pl. 36.).

In certain argillaceous deposits, as the galt of the Chalk, and the clays of the Lias, Ammonites with the shell preserved are abundant; generally the outer opaque layer is wanting, or adheres to the matrix when a specimen is removed, leaving only the internal nacreous, or pearly coat. Folkstone, on the coast of Kent, is celebrated for examples of this kind, which may easily be collected from the Galt, which forms the base of the cliffs, at Eastware Bay. Watchett, in Somersetshire, is equally rich in the pearly Ammonites of the Lias; entire layers of these beautiful organic remains occur in the clay and shale.*

The shell of the Ammonite is generally thinner and more delicate than that of the Nautilus, and in some species much resembles the flexible covering of the Argonaut; possibly, in these species, the animal, like the recent Paper Nautilus, may have possessed a pair of arms terminating in broad membranous expansions, which secreted the shell, and generally remained in contact with it; otherwise it is difficult to explain how such delicate fabrics should have been uninjured. In other species the shell is thick and dense, as in the Ammonites of the Kimmeridge Clay near Aylesbury, in which one species (*Ammonites biplex, Min. Conch.* pl. 293.) in particular abounds, and is very generally invested with the shell, as perfect as if recent. The same

* A splendid group of these Ammonites has lately been purchased for the British Museum, and may be seen in the Gallery of Fossils.

Ammonite occurs in the Portland limestone above, in the state of casts, without any vestige of the shell. In some strata the shell is replaced by calcareous spar; in others by silex or flint.* In the pyritous clays and shales of the Lias, the shell, and all its delicate internal mechanism, are transmuted into brilliant sulphuret of iron, forming the most exquisite natural electrotype imaginable. Polished vertical sections of these fossils often exhibit the inner cells filled with transparent white calcareous spar; sometimes with groups of crystals of sulphate of lime. The Ammonites of the Galt, and of the Kimmeridge Clay, are also frequently imbued with the same mineral.

There are about two hundred identified species of Ammonite in the British strata, ranging through all the secondary formations; they have not been found in the Tertiary deposits. They vary in size from half an inch to four feet in diameter.†

Certain species are restricted to particular formations, and are therefore oftentimes of essential aid in determining the relations of a deposit; for example, the *Galt* contains several species not found

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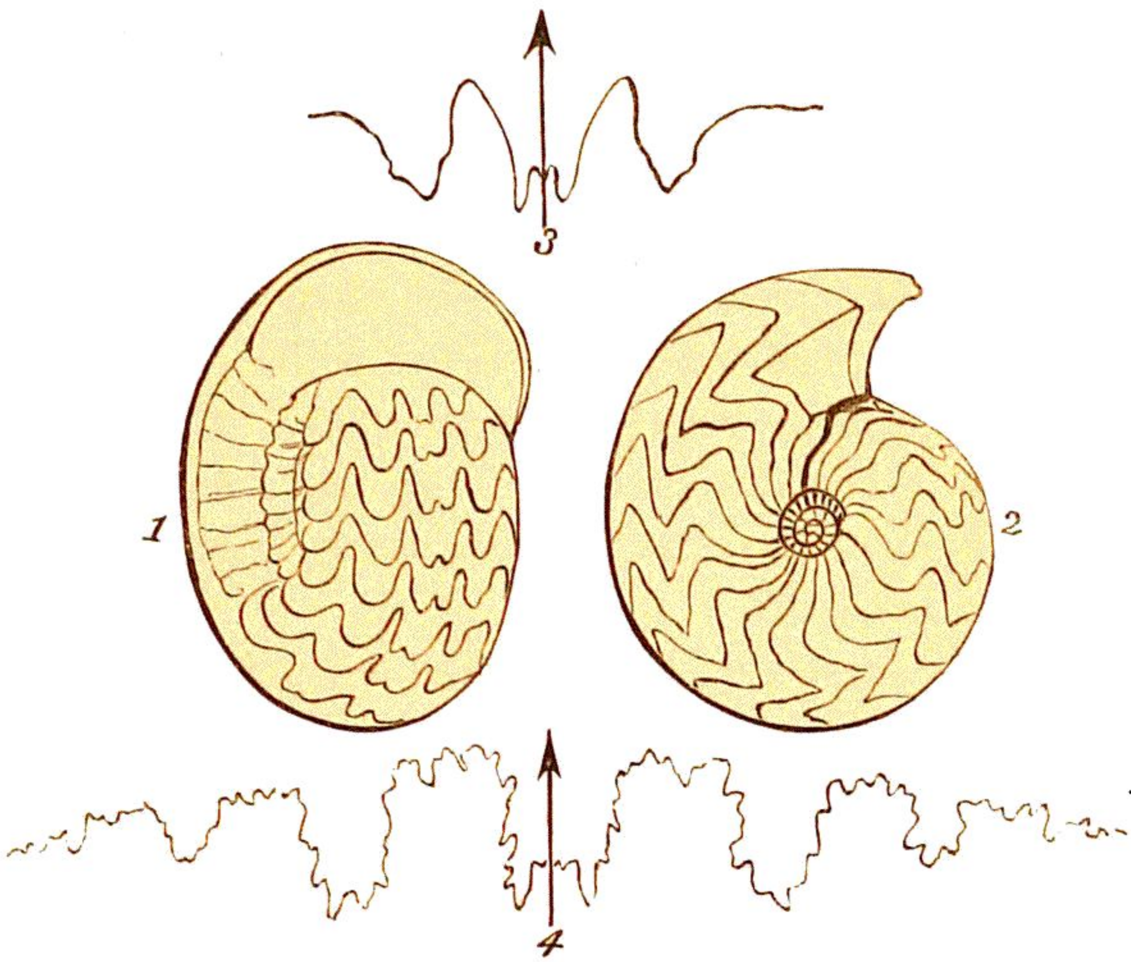
* See the admirable figure of a chalcedonic specimen, exhibiting the foliated septa of an Ammonite, discovered by Miss Etheldred Benett, *Bd.* pl. 41.

† I have seen imprints of the large Chalk Ammonite, *A. peramplus* (Min. Conch. pl. 357.), on the shore off Rottingdean, and Beachy Head, which indicated even larger proportions.

in the upper division of the Chalk; and the Chalk-marl (*Wond.* p. 313.), species not discovered in other strata. Certain Ammonites of the Lias are




LIGN. 108. GONIATITES. *Carb. and Sil. Syst.*

Fig. 1.—GONIATITES LISTERI.
2.—GONIATITES STRIATUS.
3.—Outline of a septum of a *Goniatite.*
4.—Outline of a septum of *Ammonites venustus.*
The *Arrows* in figs. 3 and 4 denote the dorsal line.

peculiar to that formation (as *A. Walcotii*, *Lign.* 91, fig. 7, p. 388.); and I have casts of this species from strata of the same epoch, from the Himalaya mountains, several thousand feet above the level of the sea.

GONIATITES, *Lign.* 108.—From the numerous family of Ammonites, a separation has been made of a large division, in which the margins of the septa are not deeply notched or foliated, and are destitute of lateral crenatures or denticulations, so that their outline always presents a continued uninterrupted line. The siphon is relatively small. The last or outer cell of the shell extends beyond one turn of the chambered part. The back is occasionally keeled, but in most species is round. In illustration of this genus, which is named *Goniatites*, I have selected two common species (*Lign.* 108.) from the Carboniferous limestone, and annexed outlines of a septum of a Goniatite, and of an Ammonite, for comparison. The importance of the separation of this type of Ammonites into a distinct genus, relates to the Goniatites being restricted to the older sedimentary strata; for although there are sixty British species, not one has been observed above the Carboniferous system.

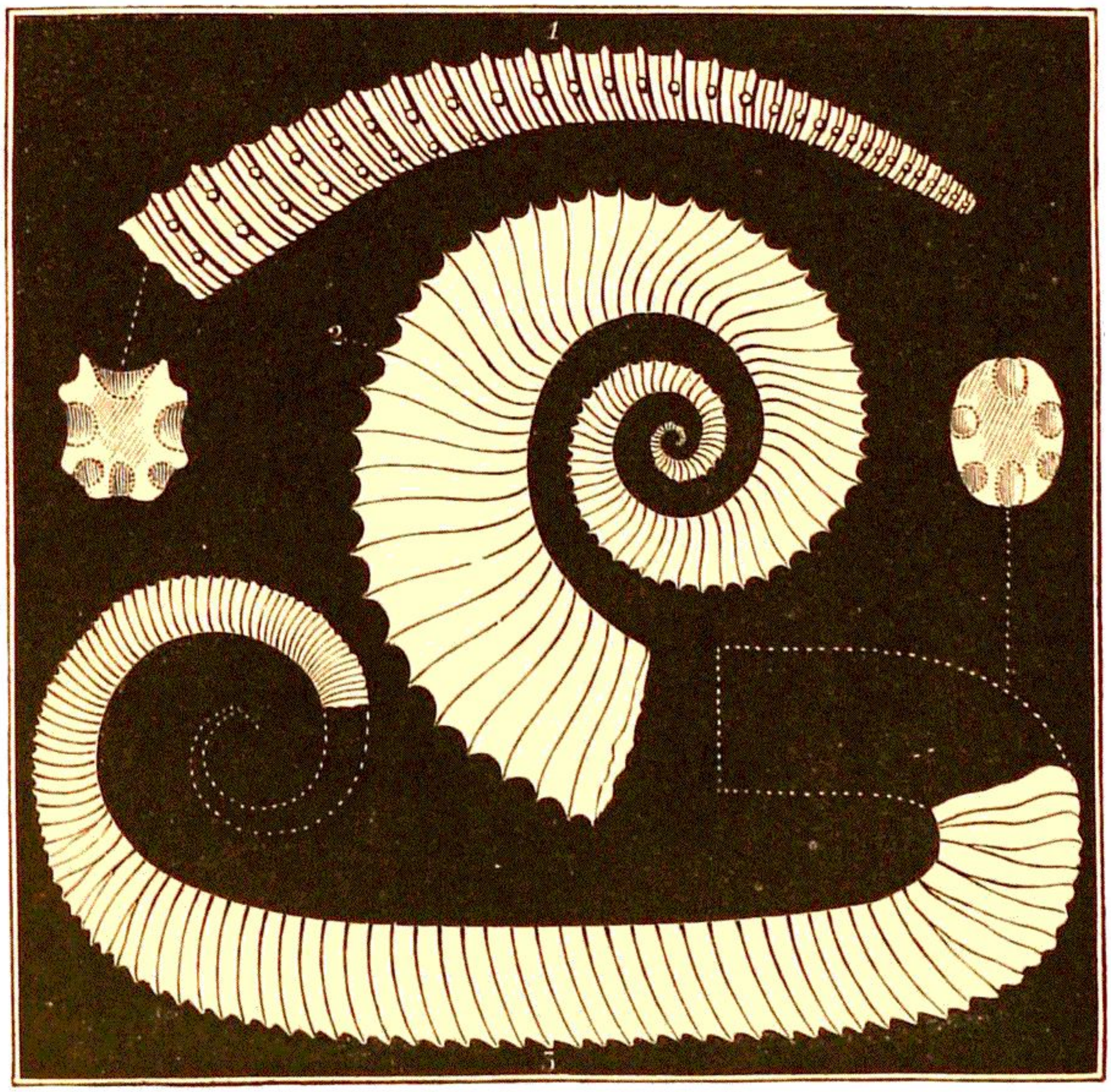
PSEUDO-AMMONITES (*resembling Ammonites*).—Associated with the remains of Ammonites in several localities of the Kimmeridge Clay, are found flattened triangular bodies, from an inch to an inch and a half in diameter, the nature of which is still problematical. A good figure is given by Mr. Parkinson of one species (*Org. Rem.* Vol. III. pl. 13, figs. 9, 10, 12.), with the name *Trigonellites lata*. These bodies frequently occur in pairs and in apposition (see *Org. Rem.* fig. 10.). Their structure is cellular; one surface is slightly concave and striated, and the other covered with minute circular pores. Altogether their appearance is that of bodies enclosed in vascular integuments; and a spathose horny substance is sometimes attached to them. It is supposed that they are the opercula of shells having the general form of Ammonites, but destitute of septa (hence the name, *Pseudo-ammonites*), such shells abounding in the Solenhofen limestone, in which these fossils also prevail. As these bodies (alluded to by authors as *Trigonellites*, *Aptychus*, &c.), will probably come under the observation of the collector among the fossils of the Kimmeridge Clay, these remarks are introduced to suggest diligent research, in the hope that the origin of these fossils may at length be discovered. The great desideratum is to find them in natural connexion with the shells, or other parts of the Cephalopoda, to which they are supposed to belong.

Our limits will not permit us to extend the notice of this very numerous family to greater length,* except to offer a few illustrations of some of the modifications in form to which we have already

* For further information Dr. Buckland's Treatise should be consulted; and the Penny Cyclopædia, which, under the respective heads of the Families and Genera of Cephalopoda, contains accurate notices of the subject.

alluded, and which will assist the student in discriminating these fossil remains.

Crioceras (*coiled-horn*), *Lign.* 109, fig. 2.—This shell differs from the Ammonites in the turns of the



Lign. 109. Shells of the family Ammonitidæ. *Cret.*

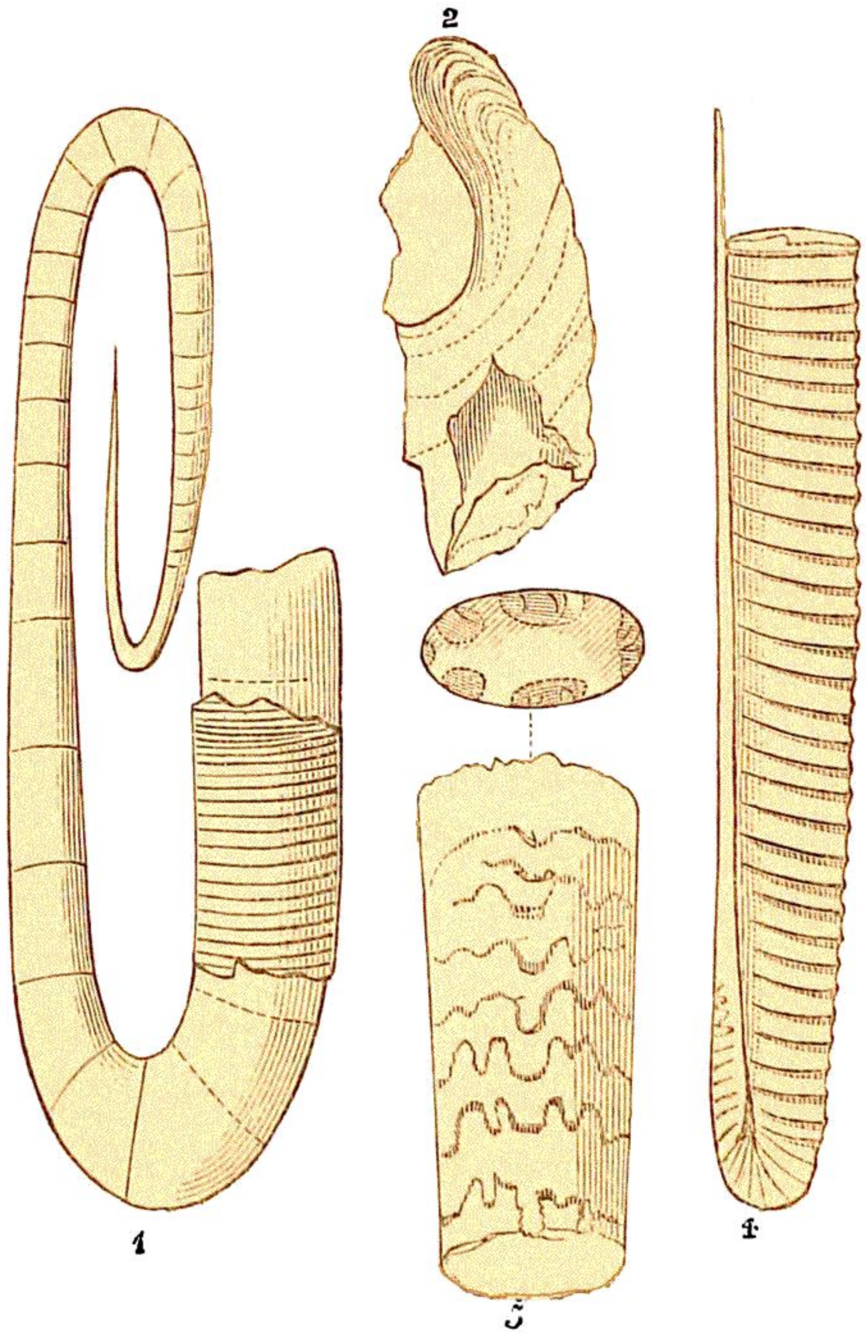
Fig. 1.—Toxoceras Emericianus, and its septum. *Hamsey.*
2.—Crioceras Puzosianus. (*M. D'Orbigny.*) *Lewes.*
3.—Ancyloceras furcatus, and its septum. *France.* (*M. D'Orbigny.*)

spire being distant from each other, and the last chamber in perfect specimens extending in a tangent from the spire. The siphon is continuous, and the septa are regularly divided into six lobes. I have found specimens of this genus in the Chalk-marl at Hamsey, and in the White Chalk, near Lewes (*Foss. South D.* Tab. XXIII. fig. 9.).

In the genus ANCYLOCERAS, *Lign.* 109, fig. 3, the turns of the spire are prolonged, and reflected at the large extremity, like a Scaphite, but the whorls are not contiguous.

A very large species of *Ancyloceras* occurs in the Kentish Rag, near Maidstone, some specimens of which are eighteen inches in length. It is figured and described, by the name of *Scaphites Hillsii*, in the admirable Memoir of Dr. Fitton on the Strata below the Chalk (*Geol. Trans.* Vol. IV. Pl. XV.); the present genus was not then established. The Shanklin Sand in the Isle of Wight also contains a gigantic species, which is figured and described by Mr. J. D. Sowerby, in the *Geol. Trans.*, as *Scaphites gigas.*

In TOXOCERAS, *Lign.* 109, fig. 1, the shell is slightly curved, like a horn. The specimens figured of these two genera, occur in the *Neocomian* strata of France. Two or three species of *Toxoceras*, are found at Hamsey. The tubercles, in the casts, are the bases of spines, with which the back of the shell was armed, as I have ascertained by examples examined in the rock (see *Foss. South D.* Tab. XXIII. fig. 1.).




LIGN. 110. HAMITES, ETC. FROM THE CHALK-MARL.

Fig. 1.—HAMITES CYLINDRACEUS, with part of the shell. (*M. D'Orbigny.*).

2.—BACULITES BACULOIDES, with the mouth entire. *Hamsey.*

3.—Part of the stem of the same species, showing the sinuous septa. A detached *septum* is figured above.

4.—PTYCHOCERAS EMERICIANUS (*M. D'Orbigny.*).

HAMITES (*hook-shaped*). *Lign.* 110, fig. 1.—Shell involute, spiral, the turns not contiguous; spire irregular, elliptical; the large end reflected towards the spire. The term *Hamite*, proposed by the late Mr. Parkinson, was formerly given to all the fragments of subcylindrical chambered shells, that were bent, or slightly hooked; and the genera *Ancyloceras*, *Toxoceras*, &c., have been separated from them, by M. D'Orbigny. But from fossils recently obtained from Cretaceous strata in Pondicherry, and other parts of India, it seems probable that these genera will be found to merge into each other; at present it is convenient to keep up the distinction. The Hamites are distinguished from Ancyloceras, which they most resemble, by their elliptical, irregular spire.

PTYCHOCERAS. *Lign.* 110, fig. 4. — This is another genus formed from the Hamites. The shell is bent double in the shape of a siphon, and the limbs are united together. The specimen figured is from the *Neocomian* strata of the Lower Alps.

BACULITES. *Lign.* 110, fig. 2.—This, as the name implies, is a straight, elongated, conical, chambered shell; the upper part is destitute of septa, and probably contained the body of the animal.

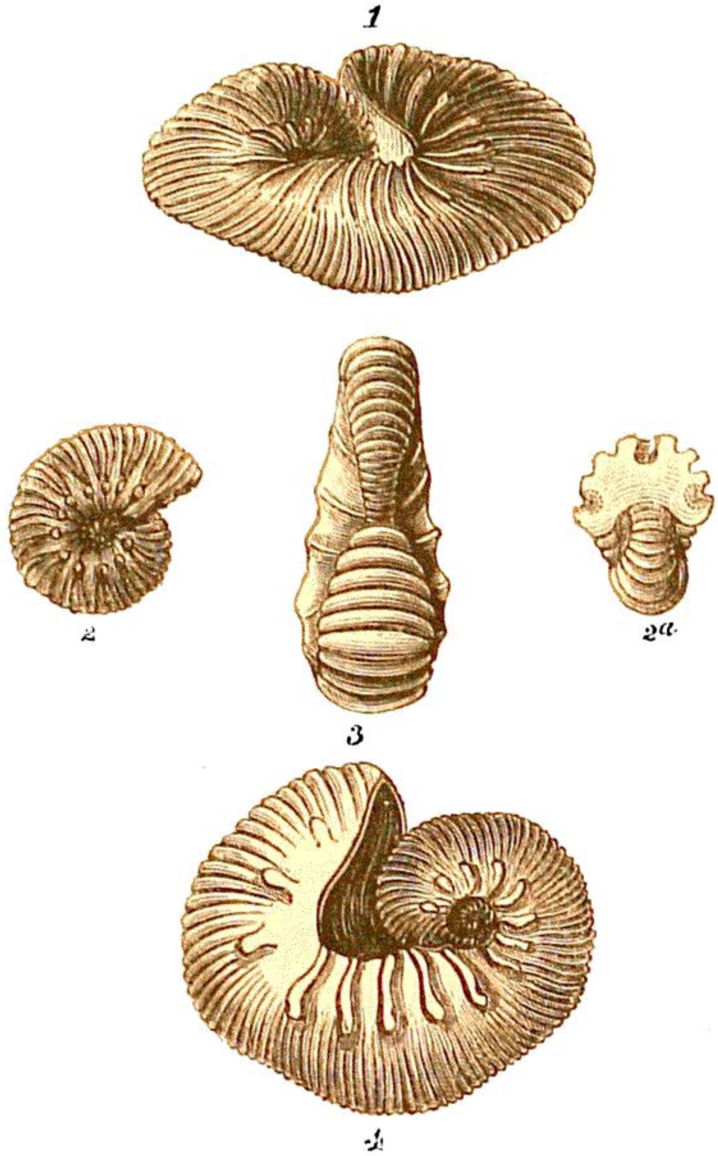
In my early researches in the Chalk-marl of Hamsey, I discovered numerous solid, oval, and cylindrical pipes of marl, with scarcely any vestige of organic structure, whose origin it was impossible to determine. At length I found the specimen *Lign.* 110, fig. 2, which showed the aperture of a chambered shell; and afterwards portions which displayed the foliated septa. (*Foss. South D.* Tab. XXIII. figs. 5, 6, 7.) The Baculite, when perfect, is elongated to a point, the septa being very numerous, and foliated; the siphon is situated on the margin. I have a splendid specimen from the Chalk of France, (collected by *M. Alex. Brongniart*,) which is composed of distinct casts of the cells, held together by the deep inflections of their margins; in the same manner as are the sparry casts of Ammonites, previously described.*

The Galt, near Folkstone, abounds in fossils of the above genera, principally of *Hamites*; and the nacreous substance of the shells is very often preserved. From the Chalk-marl near Dover, Southbourn, Ringmer, and Southerham, near Lewes; and Clayton, near Hurstperpoint, in Sussex, I have obtained examples of several species.

Scaphites (*boat-like Ammonite*). *Lign.* 111.—This name was given by Mr. Parkinson (*Org. Rem.* Vol. III. Pl. X.), to some small chambered shells from the Chalk and Shanklin Sand, of a boat-like form, with the inner whorls coiled up in a spire, and half hidden by the outer chamber, which becomes

* See Bd. pl. 44, fig. 5.

contracted and recurved on itself, is destitute of septa, and terminates in an oval or transverse mouth. The siphon is dorsal. An *Ancyloceras*,




LIGN. 111. SCAPHITES. *Chalk-marl. Hamsey.*

Fig. 1.—SCAPHITES STRIATUS.
2.—Cast in pyrites of the spiral part of a SCAPHITE.
2a.—Front view of the same specimen.
3.—Front view of SCAPHITES COSTATUS.
4.—SCAPHITES COSTATUS. (G. A. M.)

closely coiled, would be a Scaphite. Hamsey marl-pit yielded to my early researches the first Scaphites discovered in the British strata, together with Turrilites, and other cephalopodous shells, previously unknown in England.* The Scaphite is of an elliptical form, the spire and the mouth approaching close to each other; the spire occupies about one-half of the shell. Except the thick outer lip or margin of the aperture, which is almost constantly found changed into pyrites, it is rarely that any vestige of the shell remains. The same mineral constitutes casts of the spiral part; and these, when separated from the other portion, might be taken for Ammonites; see fig. 2. There are two species at Hamsey; one, with the surface covered by fine transverse striæ, which arise singly from the inner margins, and bifurcate on the dorsal part; fig. 1. The other is also striated, but has a row of prominent ribs on the inner half of the broad central portion of the shell; fig. 4. Scaphites occur in the Upper Green Sand of Dorsetshire, and in the Chalk-marl in several places in England; and at Rouen, in France; and a large species, *S. Cuvieri*, has been found in New Jersey.

TURRILITES. *Lign.* 112.—Shell spiral, more or less conical, coiled obliquely round an axis, and turriculated. Spire sinistral or dextral, whorls contiguous, apparent, with a perforated umbilicus. Septa very sinuous. Siphon continuous, situated

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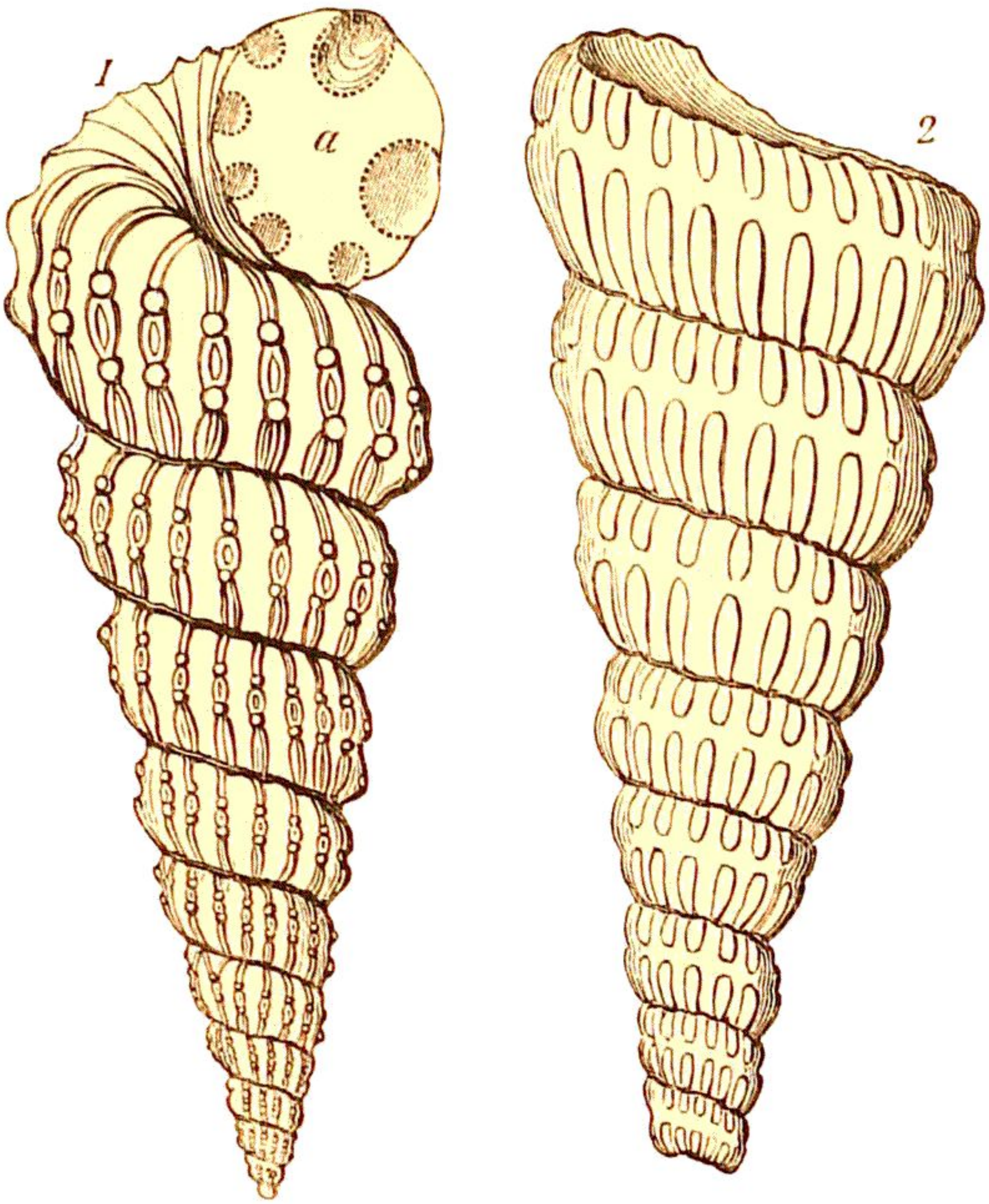
* Sow. Min. Conch. Vol. I. p. 53.

either on the external convexity, or near the suture at the base of the wreath.




LIGN. 112. TURRILITES; FROM THE CHALK-MARL.

Fig. 1.—TURRILITES CATENATUS. (*M. D'Orbigny.*) *France.*
*a.*—One of the septa.
2.—TURRILITES COSTATUS. *Hamsey.*

The discovery of three species of these elegant shells, rewarded my researches in the little marl-pit at Hamsey, already noticed, and were the first examples of the genus found in England.* Like the Ammonites, Scaphites, Hamites, &c. with which they are associated, the TURRILITES of our Chalk-marl seldom possess any traces of their shells. The specimens are solid and tolerably sharp casts, with occasional indications of the septa, and more rarely of the siphunculus. They vary in size from two or three inches to two feet in length; and are frequently more or less elliptical, from compression. The three species which generally occur in the Sussex and Kentish chalk, are *T. costatus*, *Lign.* 112, fig. 2; *T. tuberculatus* (*Foss. South. D.* Pl. XXIV. fig. 7.), characterised by its four rows of tubercles; and *T. undulatus* (*Foss. South. D.* Pl. XXIV. fig. 8.), the wreaths of which are ornamented with plain, slightly undulated, transverse ribs. These are all reversed, or *sinistral* shells; that is, the spire is twisted to the left, the aperture being on the right hand of the observer when the shell is placed on its apex, as in fig. 1. But M. D'Orbigny, the eminent French palæontologist, mentions that he has seen examples of the same species, with the spire in the opposite, or usual direction. M. D'Orbigny has figured several other species of Turrilites from the Chalk of France,† one of which, *T. catenatus*, is represented *Lign.* 112, fig. 1.

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* Sow. Min. Conch. tab. 36.

† Paléontologie Française.

Some of the Turrilites attain a considerable magnitude. The largest found in England is a specimen of *T. tuberculatus,* (*Min. Conch.* tab. 74.), from Ringmer, near Lewes; when perfect, it must have been full two feet in length: it consists of six wreaths, the siphuncle, in the state of pyrites, appearing in three or four; portions of the nacreous coat of the shell remain. In some specimens, the form of the aperture, and the termination of the columella, are distinctly preserved.

The Chalk-marl, near Lewes, and along the Sussex coast, and on that of Kent, near Dover, and the Upper Green Sand of Dorsetshire, have yielded the principal British specimens of this genus. Several species occur in the lower Cretaceous strata, at St. Catherine's Mount, near Rouen, associated, as in England, with Scaphites, Hamites, and other allied genera: these fossils often retain a thin pellicle of the nacreous lining of the shell.*

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GEOLOGICAL DISTRIBUTION OF FOSSIL CEPHALOPODA.—From this review of the principal modifications in form and structure, of the fossil Cephalopoda, the great interest which attaches to the study of this

* See "Fossils of the South Downs" for figures of many species of the Cephalopoda of the Chalk formation.

class of organic remains is strikingly demonstrated. Their geological distribution is alike replete with phenomena of an important character. In the ancient Secondary strata, we first perceive these forms of organization, belonging principally to the same family as the only known living genus, the *Nautilus*. With these are associated a peculiar group of Ammonitidæ, the *Goniatites*. The Carboniferous system contains the same genera, namely, Nautilus, Orthoceras, Cyrtoceras, and Goniatites. The New Red yields Nautili, and Ammonites (of a peculiar kind), but the Orthocerata and Goniatites have disappeared. In the Lias and Oolite, Nautili continue, and we meet for the first time with Belemnites, and the Ammonites properly so called. The same families, Nautilidæ, Ammonitidæ, and Belemnitidæ, prevail through the Cretaceous strata. The Tertiary formations contain a few Nautilidæ only; no vestiges of the Ammonitidæ and Belemnitidæ, which, as we have seen, swarmed in the ancient seas, are perceptible; while in the existing oceans, the *Nautilus* and *Spirula* are the sole representatives of the numerous genera of the ancient geological eras.

The following tabular arrangement, by Professor Phillips, will place the subject in a more distinct point of view.

| | |
|---|---|
| Existing genera . . . . . . . | Nautilus and Spirulæ. |
| Fossil in Tertiary formations. | A few of the Nautilidæ. |
| Cretaceous deposits . . . . . | Nautilidæ, Belemnitidæ, Ammonitidæ. |

| | |
|---|---|
| Lias and Oolite . . . . . . . . | Nautilidæ, Belemnitidæ, Ammonitidæ. |
| New Red formation . . . . . | Nautilidæ, and Ammonitidæ of the type called *Ceratites* only. |
| Carboniferous system . . . . | Nautilidæ, including Cyrtocerata, and Orthocerata. Ammonitidæ of the type called *Goniatites* only. |
| Devonian and Silurian. | Nautilidæ, including Orthocerata, &c. Ammonitidæ, of the type Goniatites, only. |

The distribution of the AMMONITIDÆ, in the formations in which they most prevail, namely, the Lias, Oolite, and Chalk, is thus tabulated by the same eminent geologist.

| | Ammonites. | Crioceratites.* | Scaphites. | Hamites. | Turrilites. |
|---|---|---|---|---|---|
| CHALK; viz. *White Chalk, Galt, and Marl* . . . . . . . . . . | * | * | * | * | * |
| GREEN, or SHANKLIN SAND . | * | * | * | * | |
| OOLITE *Upper* . . . . . . . | * | * | | | |
| OOLITE *Middle* . . . . . . . | * | * | | | |
| OOLITE *Lower*. . . . . . . . | * | *? | *? | | |
| LIAS . . . . . . . . . . . . . . . | * | *? | | | |

* I have added Crioceratites to the Chalk-marl, from my own observations.

With regard to the zoological affinities between the living and extinct species of testaceous Cephalopoda, Dr. Buckland remarks, "that they are all connected by one plan of organization; each forming a link in the common chain which unites the existing species, with those that prevailed among the earliest conditions of life upon our globe; and all attesting the identity of the design that has effected so many similar ends, through such a variety of instruments, the principle of whose construction is, in every species, fundamentally the same.

"Throughout the various living and extinct genera of these beings, the use of the air-chambers and siphon of their shells, to adjust the specific gravity of the animals in rising and sinking, appears to have been identical. The addition of a new transverse plate within the coiled shell, added a new air-chamber, larger than the preceding one, to counterbalance the increase of weight that attended the growth of the shell and body of these animals" (*Bd.* p. 380.).

The occurrence of the Nautilus, and its congeners, among the earliest traces of the animal kingdom, and their continuance throughout the immense periods during which the family of Ammonitidæ was created, flourished, and became extinct, and the existence of species of the same genus at the present time, are facts too remarkable to have escaped the notice even of those who are not professed cultivators of geological science; and I am induced to quote the following beautiful lines, by

Mrs. Howitt, to impress this interesting phenomenon more strongly on the mind of the youthful reader.

TO THE NAUTILUS.

"Thou didst laugh at sun and breeze,
In the new created seas;
Thou wast with the reptile broods
In the old sea solitudes,
Sailing in the new-made light,
With the curled-up Ammonite.
Thou surviv'dst the awful shock,
Which turn'd the ocean bed to rock,
And chang'd its myriad living swarms,
To the marble's veined forms.

"Thou wast there, thy little boat,
Airy voyager! kept afloat,
O'er the waters wild and dismal,
O'er the yawning gulfs abysmal;
Amid wreck and overturning,
Rock-imbedding, heaving, burning,
Mid the tumult and the stir,
Thou most ancient mariner!
In that pearly boat of thine,
Sail'dst upon the troubled brine!"

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ON THE COLLECTION OF BRITISH FOSSIL CEPHALOPODA.—In the Tertiary formations of England, the remains of but six species of Nautilus have been noticed; the large species (*N. imperialis*) is the most common. These are generally in a good state of preservation, and only require the usual careful removal of the surrounding clay or marl. When pyrites largely enters into the composition of the specimens, the investing matrix can seldom be effectually removed; and if the outer surface, and general form, be not well displayed, breaking the specimen will often expose the inner cells, with the siphunculus, in a beautiful state. The *Nautilus imperialis* is occasionally imbedded in the septaria of the Isle of Sheppey, and of Bognor, and Bracklesham, on the Sussex coast. Sections of such examples, in the vertical direction of the enclosed shell, afford, when polished, very brilliant and interesting fossils; the septa, and the shelly tube of the siphunculus, are often preserved.

The Cephalopoda of the Cretaceous formation, with the exception of those in the argillaceous strata of the Galt, are destitute of their shells, and occur as casts. The Chalk Nautili are liable to separate at the divisions of the septa, and an entire series of these casts may sometimes be obtained, so as to display the perfect form of the original shell. The Ammonites of the White Chalk, although mere casts, yet retain their configuration, the foliated margins of the septa dove-tailing them together. I have already mentioned that search should be made along the back of these specimens for the siphunculus, the shelly tube of which is sometimes well defined. In the Chalk-marl the casts are sharper, and generally of a deep ochreous colour, with the lines of the sinuous septa clearly defined. The siphuncle is occasionally preserved in pyrites, in the Ammonites, Nautili, Turrilites, and Scaphites; and the outer lip, or margin of the mouth, or aperture, of the latter, and of the Ammonites, is frequently replaced by the same mineral.

The Ammonites, Hamites, &c. of the Galt, have their nacreous or pearly shell remaining, but this investment is extremely delicate; and, although when first removed from the marl, it is beautifully iridescent, the vivid hues are very evanescent, and the shell becomes opaque, and of a light fawn colour. Very commonly the shell flakes off, wholly or in part, leaving a cast of indurated, or pyritous marl. I have preserved specimens with the shell many years, by applying a thin coat of mastic varnish with a soft camel-hair pencil, before the marl had become dry, and while the shells were entire. The Galt Ammonites, like the Nautili of the London Clay, are often invested with pyrites, and have the inner cells and siphuncle well preserved.

The argillaceous strata of the Ooolite and Lias, contain Ammonites, &c. in much the same state of mineralization as those of the Galt. The Kimmeridge Clay, in some localities, particularly around Aylesbury, (and especially at Hartwell Park, the seat of Dr. Lee,) abounds in Ammonites with the shell as perfect and beautiful as if just dredged up from the sea. But, like the fossils of the Galt, few of the specimens are durable; although in many examples the shell may be preserved, by the application of mastic varnish. The most common Ammonite at Hartwell, is *A. biplex* (*Sow. Min. Conch.*), which varies from three inches to one foot in diameter; the surface is covered by very strong ribs that encircle the whorls. The shell is thick, and composed of several laminæ.*

The sparry casts of the separate cells of Ammonites which occur in some of the calcareous beds of the Oolite, will not fail to be observed by the collector. It is convenient to preserve such specimens on a tray or board, in which a groove is made for their reception.

In collecting *Belemnites*, the caution already given, of examining the surrounding clay or marl, must not be disregarded; the student should remember, that traces of the soft parts of the animals, even of mere impressions of the body, head, tentacula, and their acetabula, or little horny rings, and hooks, are more important than the most splendid

* According to the observations of my son, the outer layers, when highly magnified, present an appearance of opaque areolæ, with irregular radiating fibres; the inner laminæ are covered with minute pores, apparently the orifices of tubuli, some of which are arranged singly in crescents, and others are confluent, like short strands of beads. I mention the fact to direct attention to the microscopic examination of the structure of these splendid fossils.

examples of the spathose durable osselet. The guards should be selected with especial reference to their containing the phragmocone (see *Lign.* 101, fig. 2.), or chambered conical shell, in the alveolus, or cavity, of the upper and larger end. An apparently worthless fragment of a Belemnite will often be found to possess this part of the structure, as in the example figured, which, until fractured longitudinally, had been thrown by among useless duplicates. The search for the fossil naked Cephalopoda, as the Loligo and Sepia, and their ink-bags, must be made in a like cautious manner. In the Lias marls, the ink-bag and its duct is often found partially covered by a pellicle of nacre, without any trace of the other parts of the animal. A reference to Dr. Buckland's plates (*Bd.* pl. 28, 29.) will familiarize the student with the appearance of these fossil remains.

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## A FEW BRITISH LOCALITIES OF FOSSIL CEPHALOPODA.

Abingdon, Berks. Ammonites, fine casts in spar and limestone.

Aylesbury, Bucks. Ammonites, several species; splendid examples of *A. biplex*, with the shell remaining, in the Kimmeridge Clay.

Bath. Fine Ammonites in the Oolite.

Beachy Head. Along the shore, gigantic Ammonites in the Chalk, at low-water.

Benson, Oxfordshire. Fine Hamites, in Chalk-marl.

Blackdown, Devonshire. Beautiful siliceous casts of Ammonites, &c.

Bognor, Sussex. Nautili, in the Tertiary Clays and Sandy Limestones ; also, along the neighbouring coast, in Septaria.

Boreham, near Warminster, Wilts. Nautili and Ammonites in Green Sand.

Bracklesham Bay, Sussex. Nautili in Clay.

Bridport, Dorset. Ammonites.

Brighton. In the Chalk, Ammonites, Belemnites, &c.

Brill, Bucks. Ammonites, as at Aylesbury.

Buxton, Derbyshire. Goniatites.

Carlingford, near Louth. Bellerophon, &c.

Charmouth, Dorsetshire. Ammonites, Belemnites, &c.

Cheltenham. Ammonites, Belemnites, Nautili, &c. in abundance.

Chicksgrove, Tisbury, Wilts. Ammonites, several species ; some chalcedonic.

Chippenham. Splendid Ammonites, Belemnites, &c.

Clayton, near Hurstperpoint, Sussex. In Chalk-marl, Ammonites, Nautili, and Turrilites ; very fine specimens.

Closeburn, Dumfrieshire. Orthocerata, the large species.

Comb Down, near Bath. Ammonites and Nautili.

Connaught, Ireland. Goniatites.

Cork. Orthocerata.

Crockerton, near Warminster. Ammonites, in Galt.

Dover. In the cliffs, and along the shore, in Chalk and Chalk-marl, Turrilites, Ammonites, Nautili, &c.

Dowlands, near Lyme. Fine Ammonites, &c. in the Marls.

Dundry, near Bristol. Ammonites, &c.

Earlstoke, Wilts. Hamites, Ammonites, &c. in Green Sand.

Faringdon, Berks. In the gravel-pits, Nautili, Ammonites, &c. In the Coral Rag, beautiful casts in limestone and spar of Ammonites, Belemnites, &c.

Folkstone, Kent. In the Galt, at Eastware Bay, in the cliff, and along the shore at low-water, Belemnites, Hamites, Crioceratites, Ammonites &c. in profusion.

Hamsey, near Lewes, Sussex. A marl-bank below the church, Turrilites, Scaphites, Hamites, Baculites, Crioceratites, Ammonites, Nautili; Belemnites, *very rare.* This pit is *unproductive*, unless recently worked.

Hartwell, Bucks, seat of Dr. Lee. Splendid Ammonites, with their shells, in Kimmeridge Clay.

Heytesbury, Wilts. Nautilus elegans, and other Chalk-marl Cephalopoda.

Horncastle. Very fine Ammonites.

Hythe, Kent. In Green Sand, large Ancyloceratites, Ammonites, &c.

Kelloway. Many beautiful Ammonites, &c.

Keynsham, near Bristol. Splendid Nautili and Ammonites; the large *A. giganteus*, two or three feet in diameter; and specimens with the chamber filled with spar, of surpassing beauty.

Lewes, Sussex. Nautili, Ammonites, &c. in the Chalk and Marl quarries of the vicinity.

London. Tertiary strata in the vicinity. Highgate Hill, fine Nautili, and Ammonites ziczac (*Bd.* pl. 43, fig. 4.).

Lyme Regis, Dorsetshire. Ammonites, Nautili, Belemnites, Sepiæ, &c. in profusion.

Lympne, Kent. Ammonites, Ancyloceratites, &c. in Green Sand.

Maidstone, Kent. Ammonites, of large size, in Shanklin Sand.

Malton. Ammonites, several large species.

Marsham, near Abingdon. Ammonites.

Marston Magna, near Ilchester. *Ammonite-marble.*

Norwich. In Chalk, Belemnites in profusion; Ammonites, &c.

Nutfield, Surrey. Fuller's-earth pits: beautiful Nautili (*N. undulatus*, and *A. Nutfieldiensis*), and Ammonites.

Offham, near Lewes. In the Chalk-pits, large Ammonites; in a Marl-pit, on the right-hand side of the road, a quarter of a mile north of the village, Hamites, Turrilites, Scaphites, Nautili, rare species of Ammonites, &c.

Oxford. Quarries in the vicinity, Ammonites, Belemnites, &c.

Roak, near Benson, Oxfordshire. In Chalk-marl, Hamites, Ammonites, &c.

Scarlet, Isle of Man. Nautili, &c.

Settle, Yorkshire. Bellerophon, &c.

Sherbourn, Somersetshire. *Ammonite-marble.*

Southerham, near Lewes. In the Chalk-pits, large Ammonites; in the Marl, Nautili, Ammonites, Turrilites, &c.

Steyning, Sussex. In Marl-pits near the town, Belemnites (*B. lanceolatus*), Nautili, Ammonites, &c.

Swindon, Wilts. In the Portland-stone quarries, Ammonites, in abundance; principally casts of *A. biplex*, and *A. triplicatus*. In the Kimmeridge Clay in the vicinity, Ammonites with the shell preserved.

Tisbury, Wilts. In Portland-stone, fine Ammonites, often chalcedonic (see *Bd.* pl. 41.).

Watchett, Somersetshire. *Belemno-sepiæ; ink-bags* of *Sepiadæ*, &c.; splendid Ammonites.

Whitby, Yorkshire. Ammonites, Belemnites, &c. in abundance; Nautili, &c.

Yeovil, Somersetshire. Beautiful Nautili and Ammonites.

# CHAPTER XIV.

## FOSSIL ARTICULATA; COMPRISING THE CIRRIPEDES, CRUSTACEANS, AND INSECTS.

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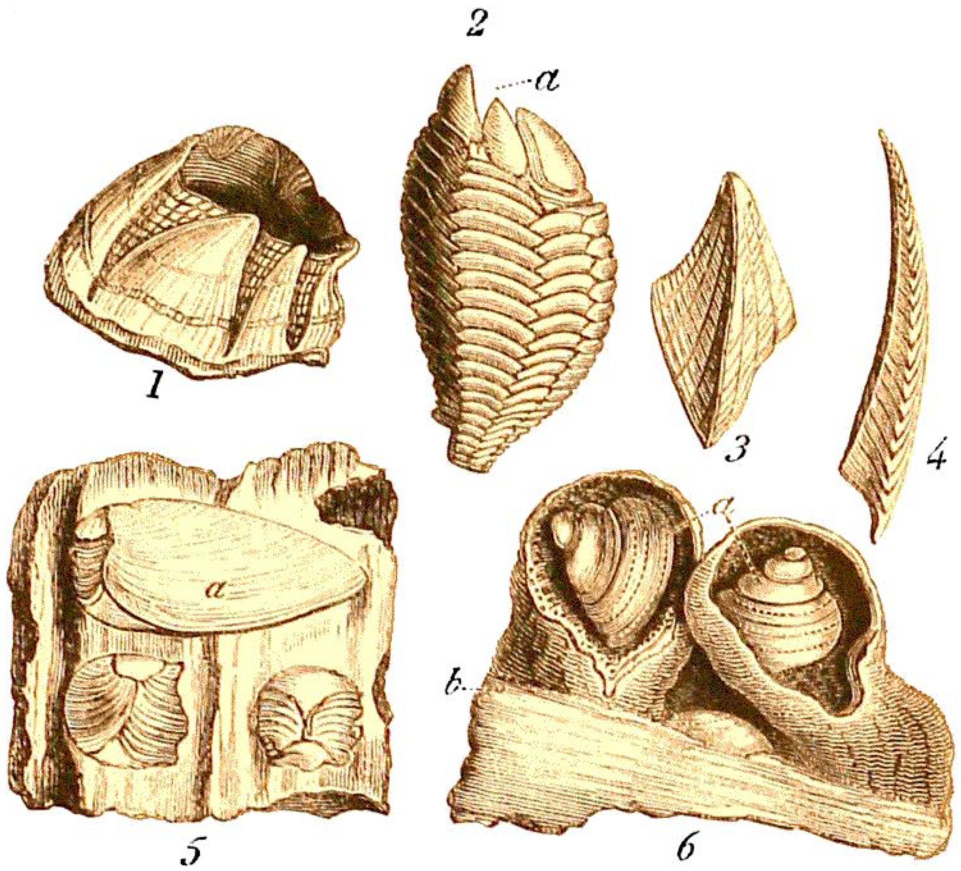
THE division of the Animal Kingdom termed *Articulata*, embraces, as the name implies, those animals which possess an external jointed skeleton, which is frequently of an annular form. It comprehends five classes; namely—

1. CIRRIPEDIA; *i.e.* having curled feet, as the *Balanus*, and *Lepas*.
2. ANNELATA, or ANNELIDA; *i.e.* formed of rings, comprising the Red-blooded Worms.
3. CRUSTACEA; as the Crab and Lobster.
4. INSECTA, or Insects.
5. ARACHNIDA, or Spiders.

The remains of each of these classes occur in the British strata, some being referable to existing, but the greater part to extinct species and genera. I propose to describe a few illustrative examples of the fossils belonging to each class, commencing with the *Cirripedes*, which have testaceous coverings so closely resembling the shells of mollusks, that they are generally figured and described as such in works on Conchology.

Cirripedia.—These animals have a soft body, enveloped in a membrane, which in some genera is protected only by a horny sheath; but in general is enclosed in a shell composed of several calcareous plates. They have six pairs of feet, terminating in long, slender, articulated tentacula, furnished with cilia, and coiled up like tendrils at the extremities near the mouth. The name of the class (*curled-feet*) has originated from the appearance presented by the curled tentacula when projecting from the oval aperture of the shell. The testaceous Cirripedes or *Barnacles* are divided into two groups; namely, the *sessile*, or those which in their adult state are fixed by the base to other bodies, as the Acorn-shell, or *Balanus;* and the *pedunculated*, which have a process of attachment, peduncle, or stem, as the Duck-barnacle, or *Lepas*. But the young animals of these genera have eyes, and powerful locomotive organs, and are capable of swimming, by sudden jerks, like some of the crustaceans, to which class, in this stage of their existence, they closely approach. But after a short period of freedom, the young Cirripede fixes itself in some locality suitable to its economy, and rapidly undergoes the transformation which results in the sessile adult Barnacle, or Lepas.*




LIGN. 113. FOSSIL BARNACLES AND PHOLADES.

Fig. 1.—BALANUS TESSELATUS. *Crag. Suffolk.*
2.—LORICULA PULCHELLA. (*Mr. G. B. Sowerby, jun.*), *Chalk. Kent.*
*a.* The aperture of the shell.
3.—A valve of POLLICIPES MAXIMUS. *Chalk. Lewes.*
4.—Posterior valve of the same species.
5.—PHOLAS PRISCUS; in wood. *Charmouth.*
*a.* One of the shells seen in profile.
6.—Univalve shells (*Neritæ*) in hollows formed by *Pholades.* (*Mr. Bensted*), *Maidstone.*
*a.* The *Nerites* lodged in the cavities.
*b.* Fragment of wood remaining attached.

* See the admirable Memoir, by J. V. Thompson, Esq., Phil. Trans. for 1835.

BALANUS. *Lign.* 113, fig. 1.—The shell of this sessile Cirripede is of a conical shape, and cellular structure. It consists of a thick plate at the base, or place of attachment; of a series of plates, united by sutures, arranged around the body of the animal, and called *parietal* valves; and of pieces termed *opercular*, by which the aperture is closed. The shell of the *Balanus*, so common on the rocks of our shores, and on every pile and pier within reach of the tide, is composed of six parietal, and four opercular valves. The fossil *Balanus*, *Lign.* 113, fig. 1, is from the CRAG, a formation containing many shells of this genus: in this example, the six parietal plates of the conical shell only remain, but in some specimens the opercular valves are also preserved. Balani have not, I believe, been found either in the older Tertiary, or in any of the secondary formations of England. In the newer *Pliocene* deposits of the Sub-Apennines, and of North America, several species are common.

POLLICIPES. *Lign.* 113, figs. 3, 4.—The pedunculated Cirripedes, of which the common *Duck-barnacle* is a well-known example, have a strong, muscular, hollow stalk, or peduncle, which supports a multivalve shell, containing the body of the animal. In the genus *Pollicipes* there are small calcareous plates covering the junction of the body with the peduncle. Detached valves of more than one species are met with in the Chalk, Galt, and Shanklin Sand, of Kent and Sussex. Eight British species are enumerated;* it is, however, probable that the specimens belong but to four or five. No connected valves have been observed, unless a beautiful and unique specimen, recently discovered by Mr. Wetherell,† in the Upper Chalk, near Rochester, be referable to this genus. A representation of this choice fossil is given *Lign.* 113, fig. 2, from a figure by Mr. G. B. Sowerby, jun.,‡ who has described it by the name of LORICULA PULCHELLA, conceiving that the presence of eight series of scales on the space which would have been occupied by the peduncle, separates this shell from all known genera. There are three pairs of valves at the apex; the aperture through which the ciliated tentacula would protrude in the living state is indicated at *a*. Mr. Sowerby remarks, that the loricated part of the shell contracts so much at the base, as to render it doubtful whether it ever possessed a muscular or tendinous peduncle; and sagaciously suggests that the animal may have dwelt, like some genera of existing Cirripedes, in hollows formed in the sponges, or other amorphozoa, so common in the Chalk formation.

ANNELIDA.—This name is given to a class of *Articulata*, consisting of worms, whose bodies are

* Mr. Morris, Cat. Brit. Foss.

† A gentleman well known for his successful and indefatigable geological researches in the London Clay, near his residence, Highgate.

‡ Annals Nat. Hist. Sept. 1843.

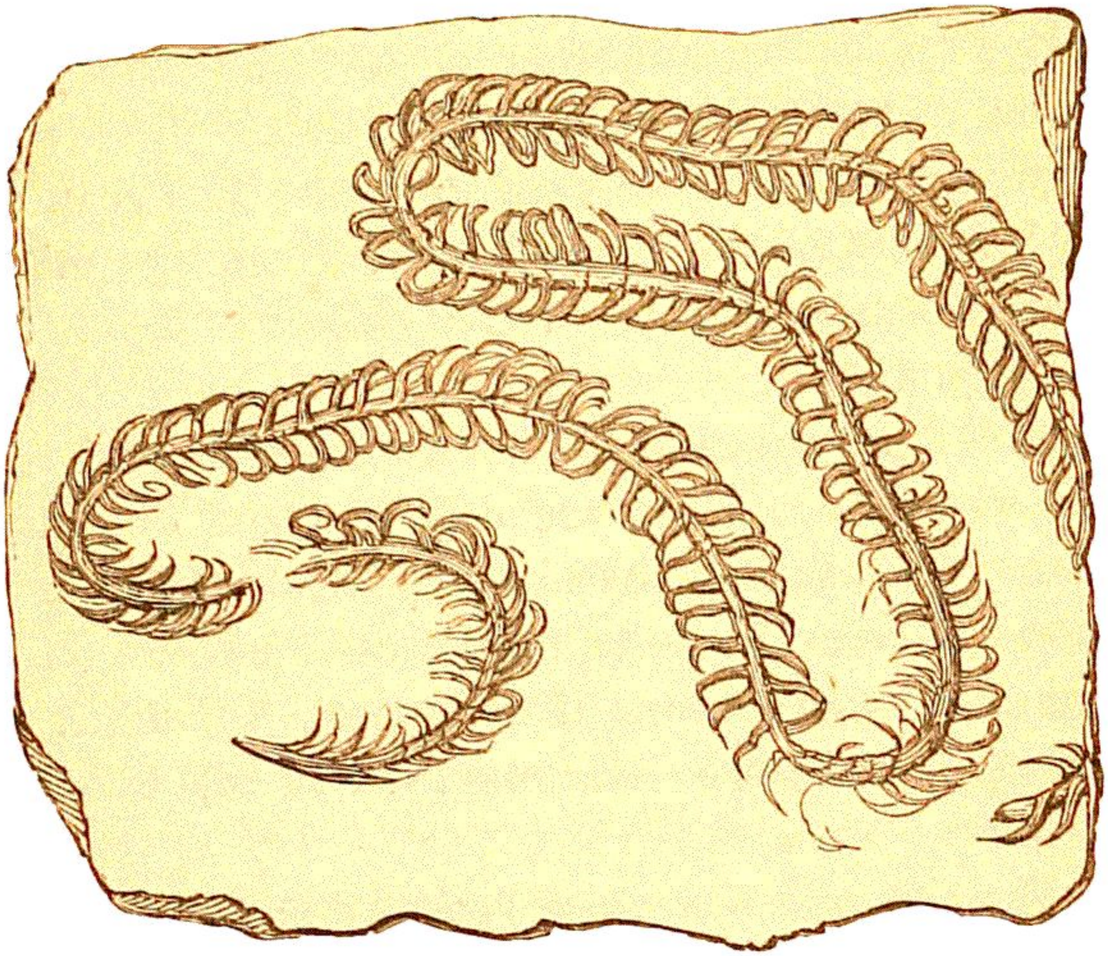
formed of little rings, or annular segments, and which have red blood; as the Leech, Earth-worm, &c. Some are naked, and move with great celerity; as the *Gordius*, or Hair-worm, and the *Nereis*, so frequent on the sands of the sea-shore. Others have shelly coverings, as the *Serpula*, and are sedentary, or fixed to other bodies; and some perforate and inhabit shells and corals. The soft bodies of certain species are protected by a coat, or tube, formed by the agglutination of sand, or other foreign substances, as in the *Sabella* (*Lign.* 87, fig. 6, p. 375.).

The fossil remains of the testaceous Annelides, are very abundant in some deposits; and even the naked, flexible, soft-bodied forms have left proofs of their existence in some of the most ancient sedimentary rocks; traces of six species, belonging to four genera, having been observed in the Silurian strata.

The first notice of these remarkable remains appeared in the invaluable work of Mr. Murchison (*Sil. Syst.* pl. 30.). "Singular convoluted impressions had been observed by the Rev. A. Oliphant, of Llampeter College, on the surface of the building-stone of that place; and, upon submitting some specimens to the examination of Mr. W. Macleay, that profound naturalist pronounced them to have been formed by sea-worms."* The living species

* Murch. Sil. Syst. p. 699.

of NEREIS, are free, agile animals, having a distinct head, provided with either eyes or antennæ, or both; they are the most perfect in structure of all the Annelides. The fossil represented in *Lign.* 114,



See also http://education.gtj.org.uk/storage/Components/513/51346_2.JPG

LIGN. 114. FOSSIL NEREIS. *Silurian strata.*

(*Drawn by Miss Murray.*)

NEREITES CAMBRENSIS. (*Murch. Sil. Syst.*) *Llampeter.*

indicates that the body of the original was composed of about one hundred and twenty segments; the feet were half the length of a segment of the body; and the *cirri* of the feet were longer than such segment.

A more slender species, the body consisting of a greater number of segments, is also figured and described by Mr. Murchison.* Other impressions have been noticed in the same stone, which resemble those that would be produced by Annelides, related to the *Gordius*, or Hair-worm.†

SERPULA.—The animals of this genus are sedentary or fixed, having calcareous tubes or shells, but to which they have no muscular attachment. They have plumose or arborescent gills affixed to the anterior part of the body. The shelly tubes of the *Serpulæ*, are constantly seen on our coasts, encrusting stones, rocks, shells, sea-weeds, &c., and may be known by their contorted or twisted forms. There are about fifty British fossil Serpulæ. A large species has been discovered by Mr. Murchison, in the Silurian rocks (*Sil. Syst.* pl. 5. fig. 1.); several occur in the Carboniferous, Oolitic, and Cretaceous, and many in the Tertiary strata. In the Upper Chalk, a smooth tortuous *Serpula* is not uncommon (*S. plexus*, *Min. Conch.* tab. 598.); it occurs in masses several inches long. But I have not observed either in the Chalk, or in any other deposit, indications of banks of *Serpulidæ*, like those now in progress off the Bermudas, and which resemble coral-reefs in their solidity and extent.

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* It is named *Nereites Sedgwickii.*

† Murch. Sil. Syst. p. 701.

## FOSSIL CRUSTACEANS.

The animals whose fossil remains we have now to consider, are characterised by their crustaceous external integument or shell, which is disposed in segments, more or less distinct, the annular portions supporting articulated limbs or appendages. They are aquatic, free, locomotive beings, and possess distinct *branchiæ*, or organs fitted for aquatic respiration. The Crab and Lobster are examples of those tribes in which the external crust is calcareous, and "coloured by a pigmental substance, diffused more or less irregularly through it; and is formed upon and by a vascular organized integument, or *corium*, which is lined by the smooth serous membrane of the visceral cavities."* The subdivisions of this class have relation to the forms, combinations, and proportions of the primary rings or segments of the external crust or integument, but it will not be requisite for our present purpose to enter upon this department of the subject. It may, however, be necessary to mention, that in the normal type of Crustaceans, the integument consists of twenty-one rings or segments, which form the three regions into which the body is divided; namely, the head, or *cephalic*, the *thoracic*, and the *abdominal*;

* Professor Owen's Lectures.

each of which is assumed to consist of seven rings, although some of these are generally anchylosed, and form but one segment; and even the three regions are occasionally more or less blended together. The *cephalic* portion of the crust contains the principal organs of sense, and the commencement of the digestive apparatus, and includes the masticatory appendages. The *thoracic* portion is formed of the rings to which the extremities serving for locomotion are attached; and, together with the cephalic, contains almost all the viscera. The consolidation of the rings or segments takes place most generally in the cephalic, and next in frequency in the thoracic; and but rarely occurs in the abdominal region. These animals possess organs of sight variously modified, and in some species highly complicated; some have smooth or simple eyes (*stemmata*), and others compound eyes, like those of insects, with distinct facets. In one grand division, (called *Edriopthalmia*,) the eyes are sessile, and immoveable; in the other (*Podopthalmia*), they are supported upon moveable stems or peduncles. These few remarks on the organization of the recent crustaceans are required, to make our description of the fossil remains intelligible to the general reader. As the shell, or calcareous integument, even in those species in which it is very dense and thick, is moulded upon the soft parts it envelopes, the experienced naturalist is able, from its configuration alone, to obtain certain conclusions as to the form, size, and position of the contained viscera; and thus the fossil carapaces may afford important data regarding the structure and economy of the extinct species. M. Desmarest* was the first naturalist who successfully applied this phrenological method to the investigation of the fossil crustaceans; and, as these animals annually shed their solid case, and acquire a new one, which is moulded on the soft parts, the form and relative situation of the internal organs must necessarily be faithfully represented by the external integument, even when it has acquired its greatest degree of consolidation; thus the regions of the stomach, heart, branchiæ or respiratory organs, &c. may be distinctly traced on the external shell.†

The fossil remains of Crustaceans consist of the calcareous covering or carapace, with the articulated extremities, and, rarely, the jaws, and antennæ. For the most part the specimens are mutilated, and present only portions of the carapace, and abdominal segments, and detached claws; but in strata composed of very fine detritus, such as the cream-coloured limestones of Solenhofen, and Pappenheim, examples often occur in the most beautiful state of preser-

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* Histoire Naturelle des Crustacés Fossiles; par MM. Alex. Brongniart et Desmarest. 1 tom. 4to. Paris, 1822.

† The student who would enter upon this much-neglected department of Palæontology, should consult the work referred to, p. 73, *et seq.*

vation, appearing as if the animals had been carefully embalmed in a soft paste, that had quickly consolidated around them, and preserved them without mutilation or blemish. In some examples, even the colour of the original remains. The specimens found in hard limestones, and coarse conglomerates, are generally mutilated, and as the under surface of the carapace, and the sternal plates to which the legs are attached, present more irregularity than the dorsal portion of the shell, they are firmly impacted in the stone, so as to render the development of some of the most important characters difficult, if not impossible. The antennæ and claws are often separated, or altogether wanting; the most common relics being the pincers, and the carapace, or united cephalo-thoracic segments. The substance of the shell, which in the recent state consists of phosphate and carbonate of lime, with gelatine or cartilage, is commonly a friable carbonate of lime, tinged with oxide of iron. These remarks apply more particularly to the crabs, lobsters, shrimps, prawns, &c. Numerous species of the smaller crustaceans, as the *Cypris*, and the extinct family of *Trilobites*, occur in myriads, and in some formations, are the principal constituent of deposits of great thickness and extent.

The remains of this class have been found throughout the vast series of the fossiliferous strata. Extinct forms appear in prodigious numbers in the most ancient formations, and are succeeded by genera which approach more nearly to the higher organized crustaceans. The Crab and Lobster tribes are represented by certain species in the Lias, Oolite, and Chalk; while in many of the Tertiary strata, the existing types prevail.

The London Clay, in the Isle of Sheppey, yields many beautiful examples of the higher order of crustaceans, as the Crab, Lobster, &c. In the Chalk these remains are more rare, but a few fine specimens have been obtained. On the Continent, certain localities are extremely rich in these remains. Upwards of sixty species were discovered by Count Munster, in the Jura limestone, at Solenhofen; and the Muschelkalk of Germany has yielded several extinct genera. The beautiful state in which these fossils occur, is exemplified in the specimen from Solenhofen, figured in the frontispiece of this work; Pl. I. fig. 2.

FOSSIL CRABS.—Of the *brachyurous*, or short-tailed, crustaceans, of which the common Crab is an example, there are the remains of several genera in the Tertiary deposits. The Isle of Sheppey is the most productive locality in England.* The carapaces of several kinds of Cancer or Crab, occur in the septaria and nodules of indurated clay; the chelate (*pincer-claws*) hand-claws are often found

* Mr. Parkinson states that upwards of thirty species of crustaceans have been found in this locality.

detached, and sometimes in connexion with the shield. The most numerous specimens are referable to two species. One of them (*Cancer Leachii*) is from two to three inches wide, and has a convex shell, the surface of which is covered by minute punctuations, with three tubercles on each anterior lateral margin.* The carapace of the other species is more distinctly lobed, and studded with aculeated or spiny tubercles; it is named *C. tuberculatus*.†

A species of Crab, characterised by its relatively large claws, is common in the soft Tertiary limestone of Malta; and examples, in a fine state of preservation, are often seen in cabinets; a specimen in my possession is figured, *Wond.* p. 237. I am not aware that any vestiges of the genus Cancer have been observed in the British Secondary formations, but several small species of brachyurous crustaceans, of the family *Canceridæ*, have been found in that division of the Chalk termed the Galt.

In the *Galt*, or blue Chalk-marl, at Ringmer, a village near Lewes, I discovered, many years since, four or five species of small crustaceans of the Crab family, which are figured and described, *Foss. South D.* Pl. XXIV.; their natural relations were pointed out to me by the late eminent naturalist, Dr. Leach. Specimens of two of the species have

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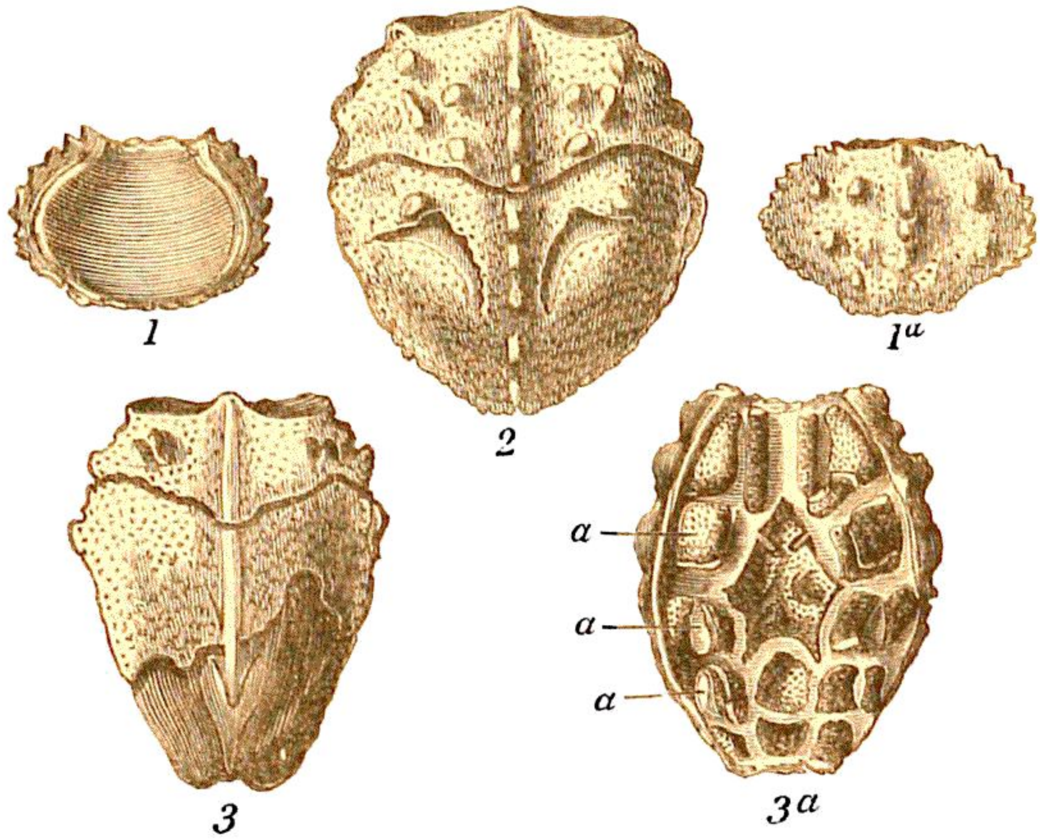
* Hist. Nat. Crust. Foss. Pl. VIII. figs. 5 and 6.

† Mr. König, Icones Foss. Sect. p. 54.

since been collected at Folkstone, but as these are only the carapaces, no additional light has been




LIGN. 115. FOSSIL CRUSTACEANS: *nat. Galt. Near Lewes.*

Fig. 1.—ETYUS MARTINI* (G. A. M.); showing the empty carapace or shell.
1a.—The dorsal surface of the same.
2.—CORYSTES STOKESII (G. A. M.). *Ringmer.*
3.—CORYSTES BRODERIPII (G. A. M.). *Ringmer.*
3a.—The under surface of the same species, displaying the sternal plates and the bases of the claws, three of which are marked *a, a, a.*

thrown upon the structure of the originals. The smallest species consists of the carapace or cephalo-

* This specific name is in honour of my friend, P. J. MARTIN, Esq. author of several excellent Memoirs on the Geology of Western Sussex.

thoracic segments, united into a transversely obovate, obscurely trilobate, shell, the surface of which is covered with minute irregular papillæ; with four tubercles on each lateral portion, and an irregularly tuberculated dorsal ridge (see *Lign.* 115, fig. 1, 1[a.]); it belongs to the genus *Etyus* (*E. Martini*).

There are two species that may be referred to *Corystes*, a genus which includes several recent crustaceans that inhabit our shores, and are characterised by their elongated oval shell, and four antennæ, the external pair, long, setaceous, and furnished with two rows of cilia. The tail is folded under the body when the animal is in repose. They have ten legs, the anterior pair *chelate* (*with pincers*), the others terminating in an acute elongated nail or claw. The fossils consist of the carapace, and one example possesses the inferior or thoracic plates, and the remains of the bases of some of the legs (see *Lign.* 115, fig. 3[a.]).

Corystes Stokesii (G. A. M.). *Lign.* 115, fig. 2.—The carapace is relatively wider than in most species of this genus: it has a strong dorsal ridge of irregular oblong tubercles: the union of the cephalic and thoracic segments is marked by a transverse undulated groove; there are three or four tubercles on the surface of each lateral portion of the former, and one on each of the latter. The whole surface is finely granulated. The openings left by the attachment of the peduncles of the eye, remain.

CORYSTES BRODERIPII (G. A. M.). *Lign.* 115, fig. 3. —This species, like the former, has a transverse undulated furrow, indicating the union of the cephalic with the thoracic segments; the dorsal ridge is smooth, and there are two tubercles on each lateral cephalic portion of the shield. The carapace is longitudinally ovate, much depressed, with three sharp points directed forwards on each margin of the anterior part: the whole surface is finely granulated. In the specimen fig. 3[a.] the sternal plates, with portions of the first joints of the claws, remain; one example (figured *Geol. S. E.* p. 169.) possessed six or seven arcuate abdominal segments, which were turned under the body. Although these two species are referred to the genus *Corystes*, they are strictly more nearly related to some Indian genera of the family *Corystidæ.*

The carapace, or shell of the other crustacean observed in the Sussex Galt, is of an orbicular inflated form (see *Geol. S. E.* p. 169, fig. 3.), and ornamented with twelve or thirteen aculeated tubercles; its margin is dentated. It is related to the genus *Arcania;* I would distinguish it by the name of *A. Bucklandi.**

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* I have described these small crustaceans somewhat minutely, and given them specific names, in the hope of directing the attention of collectors to these highly interesting relics, and leading to the discovery of more illustrative examples. See Foss. South D. p. 96, 97.

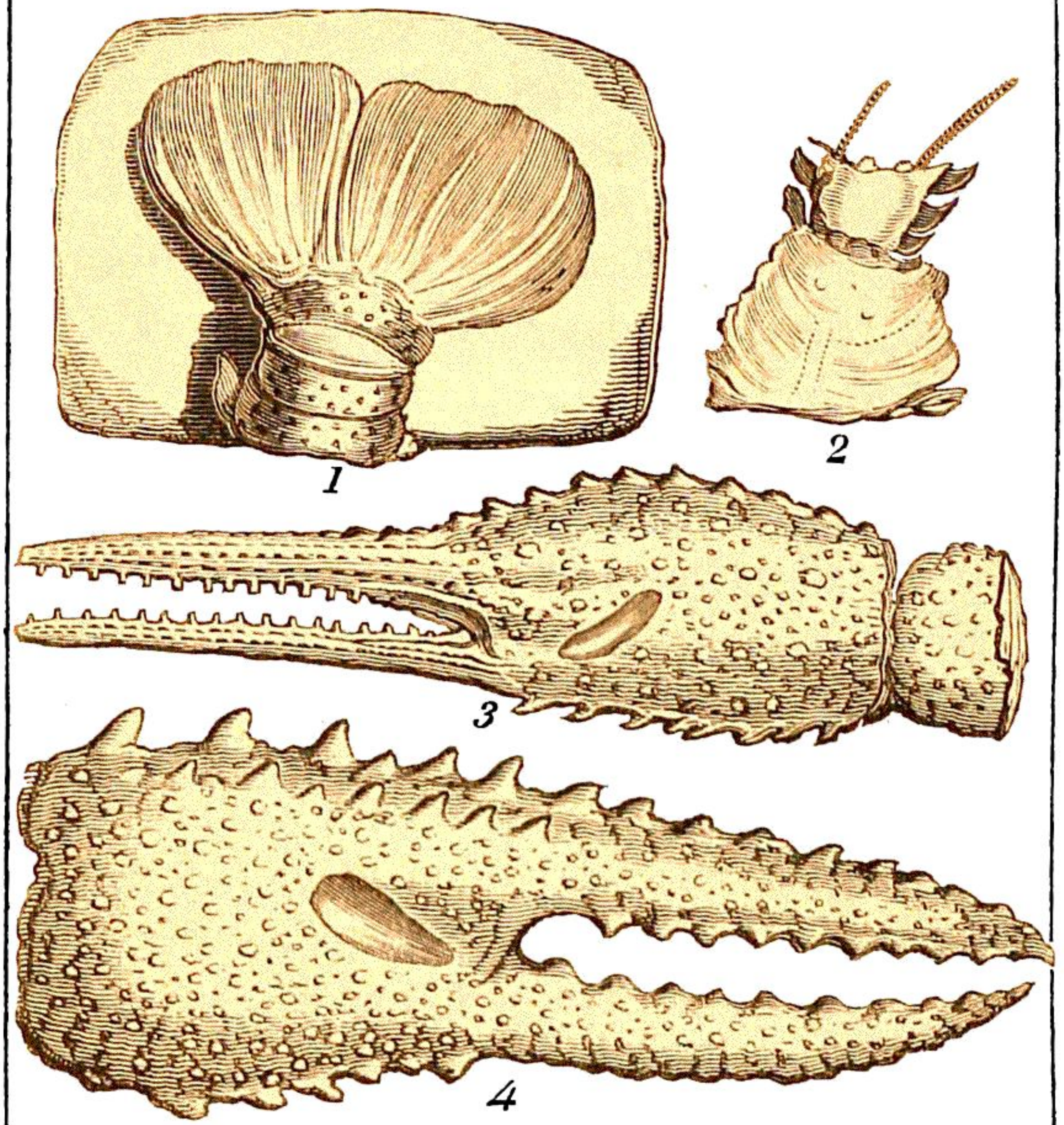
The *macrourous*, or long-tailed, crustaceans, as the *Lobster*, are distinguished from those of the former division, by the prolonged abdomen, or tail, as it is commonly termed, which forms a powerful instrument of locomotion, and enables the animal to proceed backwards through the water with great rapidity; and it is furnished with an appendage or tail, which none of the ambulatory crustaceans possess.

Of the fresh-water species, the Craw-fish, (*Astacus fluviatilis*,) and of the marine, the Lobster, (*Astacus marinus*,) are illustrative examples. The remains of several species of Lobster occur in the London Clay of the Isle of Sheppey, associated with congenerous crustaceans; and the segments of the tails (*post-abdomen*) are often well preserved.

In the friable arenaceous limestone of the Cretaceous formation, at St. Peter's Mountain, near Maestricht, the cheliferous claws of a small kind of crustacean (*Pagurus Faujasii*, *Wond.* p. 327.), are frequently discovered, but with no vestige of the carapace or shell. This curious fact is explained by the analogy existing between the fossil claws and those of the *Pagurus*, or Hermit-crab, whose body is only covered by a delicate membrane, the claws alone having a calcareous covering; hence the latter might be preserved in a fossil state, while no traces of the soft parts remained. In the fossil, as in the recent claws, the right arm is the strongest. There is no doubt that the crustaceans to which the fossil claws belonged, possessed the same modification of structure as the recent hermit-crab, and must have sought shelter in the shells of the mollusks, with which their durable remains are associated.

The Chalk contains a few species, which were first discovered in the quarries near Lewes, and are figured in *Foss. South D.* Tab. XXX., XXXI.; they are among the most rare and delicate of the fossils of the Cretaceous strata. These remains consist of the carapace and claws, and rarely of the tail and antennæ, and are composed of a friable earthy crust, which, when first discovered, is of a dark chocolate colour, but quickly changes to a pale fawn, or reddish brown, by exposure to the air. In the specimens obtained by breaking the stone, the crustaceous covering remains attached by its rough external surface to one portion of chalk, and on the corresponding piece are sharp casts of the carapace, and claws, having a glossy surface covered with minute papillæ formed by the bases of tubercles or spines. Three distinct species, and indications of others, have been observed.

Astacus Leachii (G.A.M.). *Lign.* 116, figs. 1, 2, 3. —This is a long delicate crustacean, having a pair of equal, slender, anterior chelate claws, the fingers of which are long, attenuated, and armed with a row of obtuse cylindrical spines. The surface of the hand-claws is muricated or covered with short erect




LIGN. 116. FOSSIL CRUSTACEANS: *nat. Chalk. Lewes.*

Fig. 1.—Abdominal appendage, or tail of ASTACUS LEACHII, (G. A. M.,) with three abdominal segments.

2.—Part of the head of *Astacus Leachii,* with remains of the squamous peduncles of the antennæ, and of the long setaceous antennæ.

3.—Chelate claw, with part of the *carpus,* or wrist of *Astacus Leachii.*

4.—Chelate claw of ASTACUS SUSSEXIENSIS (G. A. M.).

aculeated tubercles. The pincers in the specimen figured *Lign.* 116, fig. 3. are shorter than in most examples. The carapace is elongated and sub-cylindrical, with a dorsal ridge and two lateral furrows, indicating the normal division of the cephalic and thoracic segments of the shield; the antennæ are long, filiform, and setaceous (*bristly*), and are placed on squamous peduncles (see *Lign.* 116, fig. 2.).

There appear to have been five legs on each side; the anterior or chelate pair are the most usual relics of this animal; of the other claws, and the branchiæ, but obscure indications have been obtained. The abdominal segments are arcuate, and six or seven in number; their surface is granulated; the appendage, or tail, is foliaceous and marginate, with a few longitudinal ridges (see *Lign.* 116, fig. 1.).* The claws of these crustaceans may be easily recognised by their general aspect, and the length and straightness of the fingers or pincers. In most examples traces remain of the tendinous expansion of the muscles of the moveable claw (see *Lign.* 116, fig. 3.).

ASTACUS SUSSEXIENSIS (G.A.M.). *Lign.* 116, fig. 4. —The claws of this species are readily distinguished from the former by their broader and stronger proportions, and spinous character; the pincers are

* See Foss. South D. p. 221, *et seq.* for further details.

strong and tuberculated, and the moveable finger is more curved, and shorter than its opponent. The carapace, and entire crust of this lobster is muricated, or beset with spines and sharp tubercles.*

Claws of other species of *Astacus* have been found in the Chalk of Sussex and Kent; one species in particular is distinguished from those previously described by its short curved pincers, and granulated surface.†

Imperfect claws of *Astacidæ* have been found in the Shanklin Sand; and I have collected the abdominal segments of a small species from the Galt at Ringmer, resembling *A. ornatus*, *Lign.* 117.

Fossil Prawns and Shrimps, of exquisite beauty, are found in the lithographic limestone of Pappenheim: a specimen from that locality (*Palæmon spinipes*) is figured *Wond.* p. 451.

A large crustacean of the Shrimp family has been discovered by the Earl of Enniskillen, in the Lias of Lyme Regis;‡ and in one specimen the *branchiæ*, or respiratory organs, remain. Lord Enniskillen has also obtained from the same rich mine of organic remains, a portion of the post-

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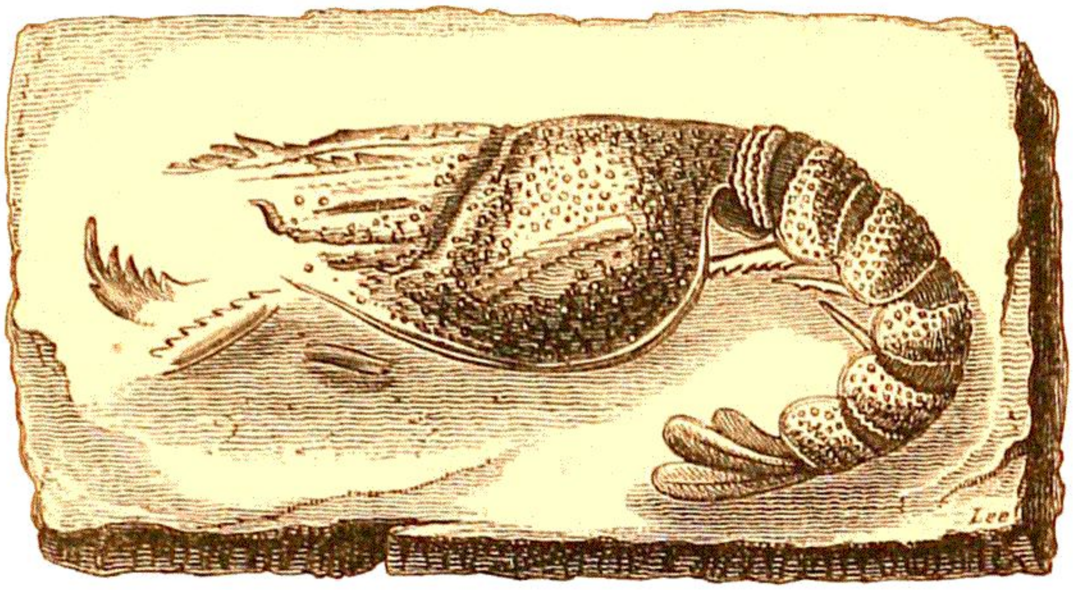
* Foss. South D. Tab. XXX. fig. 3.

† This species may be named *Astacus cretosus*, to indicate its geological habitat.

‡ This beautiful fossil is figured and described by Mr. Broderip, Geol. Trans. Vol. V. Pl. XII. by the name of *Colëia antiqua*.

abdomen, or tail, of a Craw-fish, as large as the common species.

The carapaces of two or three small *Astacidæ*, sometimes with the abdominal segments attached, as in the beautiful fossil figured in *Lign.* 117, are found in the Speeton Clay, near Scarborough. In this example the post-abdomen and its appendages are entire, and traces remain of the antennæ and some of the feet. These specimens are com-




LIGN. 117. FOSSIL CRUSTACEAN. *Oolite. Yorkshire.*
ASTACUS ORNATUS: *nat.* (*Professor Phillips.*)

monly imbedded in masses of indurated clay, like the fern-leaves of the Carboniferous ironstone, and are discovered by splitting the nodules through their longest diameter. The carapace of another small species occurs in the Oolite of Scarborough.*

* It is named *Astacus rostratus*, by Prof. Phillips, Phil. York. I. tab. 4, fig. 20.

My friend, the Rev. J. B. Reade, has discovered an example of this species in that rich repository of organic remains, the Kimmeridge Clay, at Hartwell, Bucks.

A remarkable macrourous crustacean is found at Solenhofen, of which perfect specimens are occasionally seen in collections; it is distinguished by its very large, flat, oval shell, with the front lateral margins strongly dentated, and by its short setaceous antennæ; the front claws are as long as the body, and armed with pincers; the post-abdomen consists of six segments, terminating in a caudal appendage or tail.*

In the United States several fossil crustaceans have been noticed in the Cretaceous strata of New Jersey; some of which are said to be related to *Pagurus*, and others to *Astacus*. The most remarkable remains of this class belong to a branchiopodous (*feet supporting branchiæ*, or *gills*) crustacean, described by Mr. Dekay, under the name of *Eurypterus;* it is probably from the Carboniferous limestone. The head is round, the thoracic and cephalic portions of the carapace are blended together, and the abdominal region is formed of eleven segments, with a caudal appendage. It has two depressed lunated eyes, remote from each other, and eight feet, the anterior pair furnished with branchiæ,

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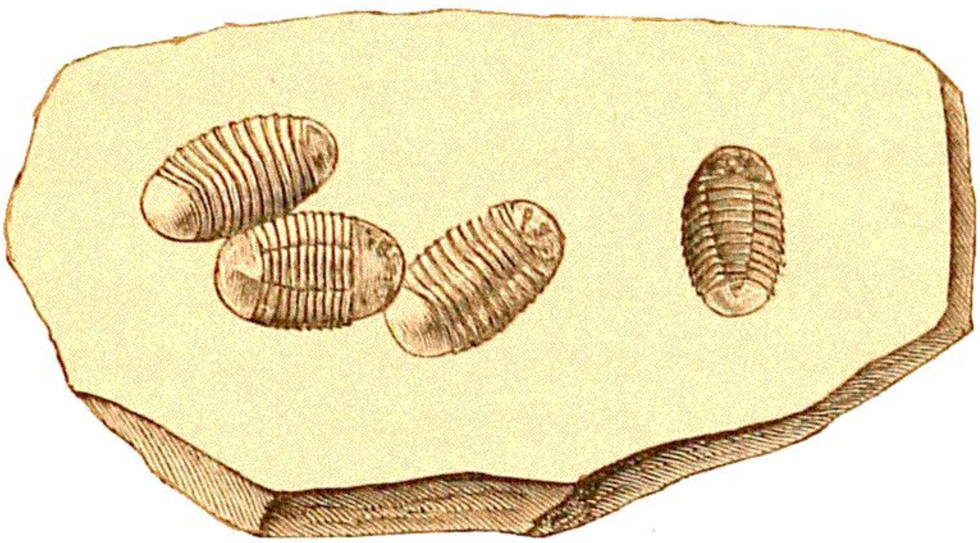
* This crustacean is named *Eryon Cuvieri*, and figured Pl. X. fig. 4. Hist. Nat. Crustacés.

and the posterior pair relatively larger than in any other crustacean. Two species are described; the one is five, the other about four inches long.* In the Carboniferous strata at Burdie-house, near Edinburgh, two species of this curious genus have been discovered by Dr. Hibbert, both of which are very large, their length being estimated at from twelve to eighteen inches.†



LIGN. 118. ISOPODOUS CRUSTACEANS. *Wealden. Vale of Wardour.*

(*Drawn by S. P. Woodward, Esq.*)

Impressions of the upper and under surfaces (*Rev. J. P. Brodie.*).

ISOPODA (*equal-feet*) is the name given to an order of crustaceans, in which the body is composed

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* Dr. Harlan, in Trans. Geol. Soc. Pennsylvania, Vol. I. p. 96.

† See the elegant Memoir on the Fresh-water Limestone of Burdie-house, near Edinburgh, by Samuel Hibbert, M.D. F.R.S. Ed.

of a distinct head, and seven rings, each having a pair of feet which are alike and equal; the common *Oniscus*, or wood-louse, is a terrestrial *Isopod*. It includes many genera and species, some of which approach very nearly to the extinct family of crustaceans whose remains are so abundant in the ancient fossiliferous strata; and the parasitical Isopod, *Bopyrus*, that infests the common Prawn, is closely related to certain genera of Trilobites, hereafter described. One species of fossil *Isopod* has been found in green fissile marl, at Montmartre; and another in fine-grained limestone, probably, from Pappenheim.* No fossil remains of this order had been noticed in the British strata, until the discovery of Isopodous crustaceans, in the Wealden strata, by the Rev. P. B. Brodie. The quarry in which these relics were found is situated at Dallards, near the village of Dinton, about twelve miles west of Salisbury. They are principally distributed in a bed of light-brown and grey limestone, in the lower part of which are numerous fresh-water bivalves (*cyclades*), and a few small oysters. These Isopods often occur in clusters (see *Lign.* 118.); the lenses of the compound eyes are sometimes detectable in the limestone, and, rarely, attached to the head; traces of legs have been observed, but no antennæ. In the same stratum the *elytron* (sheath, or wing-case) of a coleopterous insect was

* Nat. Hist. Crust. Foss. p. 138.

discovered. Mr. Brodie has obtained specimens an inch and a half in length, and an inch broad. These fossils appear to have been deposited tranquilly at the bottom of the water which they inhabited, since they are always found imbedded with their legs downwards, and generally well preserved.*

CYPRIS. *Lign.* 119 (*Wond.* p. 377.).—The animals of this genus belong to those Crustaceans in which the covering of the body is not divided into segments, but consists of a large dorsal shield, having the form of a bivalve shell. They are exceedingly minute, and numerous kinds swarm in our lakes and pools. The species of an allied genus, named *Cytherina*, the shells of which cannot with certainty be distinguished in a fossil state from those of *Cypris*, inhabit salt or brackish waters. As the living *Cyprides* are interesting objects for microscopic examination, they are commonly shown in the exhibitions of the hydro-oxygen microscope, and their appearance is therefore well known. Two recent species are figured, *Ly.* I. p. 369. These animals have the body enclosed in a bivalve, horny case, the two pieces being united by a hinge-line. They have four feet, and two straight simple antennæ, with a pencil of cilia at the extremities; and

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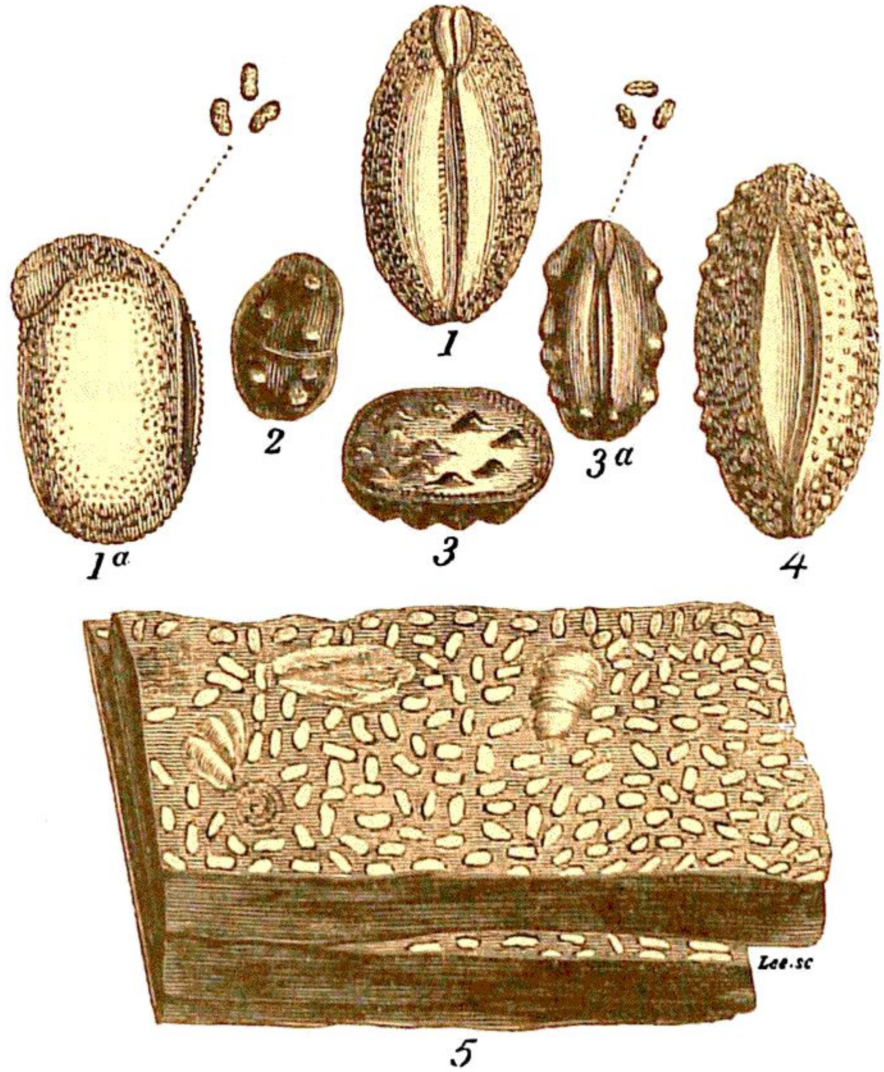
* Geol. Proc. Vol. III. pp. 134, 782.




LIGN. 119. FOSSIL CYPRIDES. *Wealden. Sussex.*

(*Drawn by Miss Jane Allnutt.*)

Fig. 1.—CYPRIS VALDENSIS: × × (*Dr Fitton*); showing the hinge-line that unites the valves. *Cooksbridge.*

1a.—Side view of the same, × ×. The three small figures: *nat.*

2.—CYPRIS FITTONI, × × (G. A. M.). *Langton Green.*

3.—CYPRIS TUBERCULATA, × × (*Dr. Fitton.*) *Langton Green.*

3a.—View of the same, showing the hinge-line; the three small figures, *nat.*

4.—CYPRIS GRANULOSA, × × (*Dr Fitton*); view showing the hinge-line.

5.—A piece of WEALD CLAY, with Cyprides: *nat.*

one compound eye. They swim with rapidity, by means of their ciliated antennæ and feet, and may be seen actively pursuing the minuter organisms on which they prey. Like the other crustaceans, they frequently moult or cast their cases, and the surface of the mud spread over the bottoms of still lakes, is often covered with their exuviæ. The largest living Cypris (*C. ornata*) does not exceed one-sixth of a line in length. The fossil cases or shells of Cyprides, are found in considerable variety and in prodigious numbers, in certain Tertiary and Secondary strata, which appear to have been deposited by fresh-water; as for example, in the lacustrine marls of Auvergne (*Ly.* I. p. 370.), and the fluviatile clays and limestones of the south-east of England. They have not been observed in any decidedly marine beds; but Mr. Lonsdale discovered among the microscopic corals of the Chalk, cases of crustaceans, that probably belong to the genus *Cytherina* (*Ly.* I. p. 57, fig. 21.), the recent species of which inhabit the sea. One species of Cypris only has been observed in the British Tertiary formations, and that was discovered by Mr. Lyell, in Hordwell Cliff (*Geol. Trans.* Vol. III. p. 288.). In many districts on the Continent, the Eocene marls and clays abound in these remains. Some of the fresh-water Tertiary strata of France contain myriads of a Cypris (named *C. faba*, from its bean-like form), which was formerly supposed to be identical with a species found in the Wealden, but Dr. Fitton (who has ably investigated the fossil remains of these crustaceans) has shown that they are distinct. The laminated marls of Auvergne contain, between every layer, countless myriads of the shells of Cyprides, through a depth of several hundred feet; although each lamina of marl scarcely exceeds the thickness of paper. Near Clermont, the green *cypriferous* marls approach to within a few yards of the granite which forms the borders of that ancient basin (*Ly.* I. p. 370.). In the eastern portion of the basaltic district of India, Mr. Malcolmson has discovered two species of Cypris, associated with fresh-water univalves and bivalves.* In England the principal deposits of the Cyprides, are the clays and limestones of the Wealden, to the composition of which the relics of these minute beings have largely contributed. Entire layers of their cases are found in the laminated clays and marls on the southern shores of the Isle of Wight, at Atherfield, and Sandown Bay, where some of the Wealden beds emerge from beneath the lower division of the Shanklin sand. Upon splitting the clay in the direction of the laminæ, the exposed surfaces are found to be covered by these minute bodies; as in the specimen, *Lign.* 119, fig. 5.

The appearance of four characteristic Wealden Cyprides, of their natural size, and magnified, is

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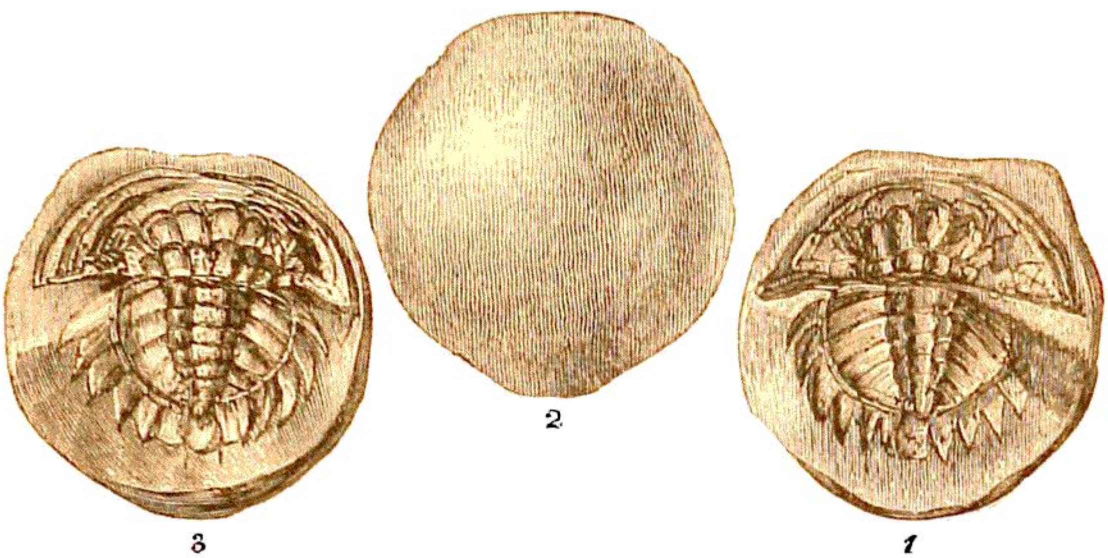
* Geol. Trans. Vol. V. pl. 47.

shown in *Lign.* 119. The one named *C. Valdensis*, or Wealden Cypris, by Dr. Fitton (fig. 1.), is the most frequent, and occurs in numerous localities in Kent and Sussex. A Cypris having the case studded with relatively large tubercles (fig. 3.), is found in many of the finer sandstones of Tilgate Forest; another, with the shell tuberculated, but divided by a transverse ridge, indicating a rudimentary condition of the segments which characterise the class (fig. 2.), is certainly distinct from the former, and can have no name more appropriate than that of *C. Fittoni.* The other beautiful species (*C. granulosa*, fig. 4.) has the surface of the case covered with granules. One more species has been observed in the Weald clay, at Sandown Bay, and Atherfield (by Mr. Lonsdale); it is distinguished by a short conical spine on each valve, and is therefore named *C. spinigera.* In the Weald clay at Resting-oak-hill, near Cooksbridge (*Geol. S. E.* p. 187.), *C. Valdensis* is so abundant, that every thin flake is covered with its white calcareous shells; and upon breaking the nodules and septaria of reddish-brown ironstone, which occur in that locality, myriads of beautiful sharp casts of the cases are observable in almost every fragment. They are associated with fresh-water bivalves and univalves (*Cyclas* and *Paludina*), and minute scales of fishes.

The Sussex marble is largely composed of the remains of these minute crustaceans. Upon examining thin polished slices of this limestone under the microscope, the cavities and interstices of the shells are found to be filled with the shields of Cyprides, entire or in fragments; and some specimens of the Purbeck marble equally abound in these remains. As the recent species inhabit still lakes, or gently running streams, and not the turbulent waters of estuaries, we cannot doubt that the strata in which these animals so largely predominate, were deposited in lakes, or bays, communicating with the river which transported to their present situation the bones and other remains of the colossal reptiles of the Wealden. And the beds of fresh-water snails, with scarcely any intermixture of other organic remains but the Cyprides, which are spread over extensive areas in the Wealden districts, appear to afford corroborative proof of this inference. The sandstone at Langton Green, near Tunbridge Wells, which contains casts and impressions of several species of fresh-water shells, abounds in *Cyprides;* and the layers of argillaceous ironstone, inter-stratified with the sandstone in one of the quarries, are particularly rich in these remains. The surface of a recently broken slab is often covered by minute, polished, oblong, convex bodies, which are the casts of cypridean carapaces. The only other known British geological habitats of this genus, belong to the Oolite and Carboniferous systems. One species has been collected at Gristhorpe Bay; and another in coal-shale, at Newcastle. An exceedingly minute Cypris has been found in the limestone at Burdie-house; and two species, in the coal-shale near Derry.*

The LIMULUS, MOLUCCA, or KING-CRAB, is a genus abundant in the seas of India and America. The carapace is crustaceous, and of a semilunar form, the




LIGN. 120. FOSSIL LIMULUS, IN A NODULE OF IRONSTONE.

*Coalbrook Dale.*

Fig. 1.—LIMULUS ROTUNDATUS (½ *nat.*), the imprint of fig. 3.
2.—The nodule before it was broken.
3.—LIMULUS ROTUNDATUS (the corresponding portion of the nodule, fig. 1.) showing the entire form of the carapace and appendages.

head and thorax are blended together, and the superior abdominal shield, which is composed of confluent segments, appears like one piece, and has

* Geological Report on Londonderry; by Capt. Portlock. 1843.

an indistinct trilobed character; the last segment is prolonged into a three-edged, sharp, styliform weapon. The Limulus has two reniform, compound eyes, composed of facets of a peculiar form. The gills are disposed on lamelliform processes. It is distinguished from all other crustaceans by the mastication of its food being performed by the first joint of the thoracic legs which surround the mouth, instead of by jaws.

Very fine examples of a fossil species of this remarkable genus are occasionally obtained from the lithographic stone of Solenhofen.* In England three very small species have been discovered in nodules of ironstone and indurated clay, in the Carboniferous strata of Coalbrook Dale. The specimen figured *Lign.* 120, is one of several examples which I obtained by breaking up nodules from that celebrated locality. Fig. 2, represents the nodule unbroken, and without any indications of its contents; by a well-directed blow, it was separated into two equal portions, figs. 1 and 3, in which the carapace of the crustacean, and its appendages, are well displayed. The rounded form of the carapace, and the membrane which appears to connect the spines, separate this species from all others. Three species of *Limulus*, and one of *Apus*, resembling the *A. corniformis* of the rivers of Central and Southern Europe, have been found in the ironstone nodules

* Hist. Crust. Foss. Pl. XI. fig. 6.

of Coalbrook Dale, by Mr. Prestwick.* In one example (*L. anthrax*†), two of the legs are seen extending from under the body. In another species, the sharp, pointed process of the tail is well developed (*Wond.* Tab. 130, p. 673.). The celebrated naturalist, Dr. Milne Edwards, considered these fossils as exhibiting characters intermediate between the recent Limuli and the extinct crustaceans which swarm in such prodigious numbers in the ancient fossiliferous strata.

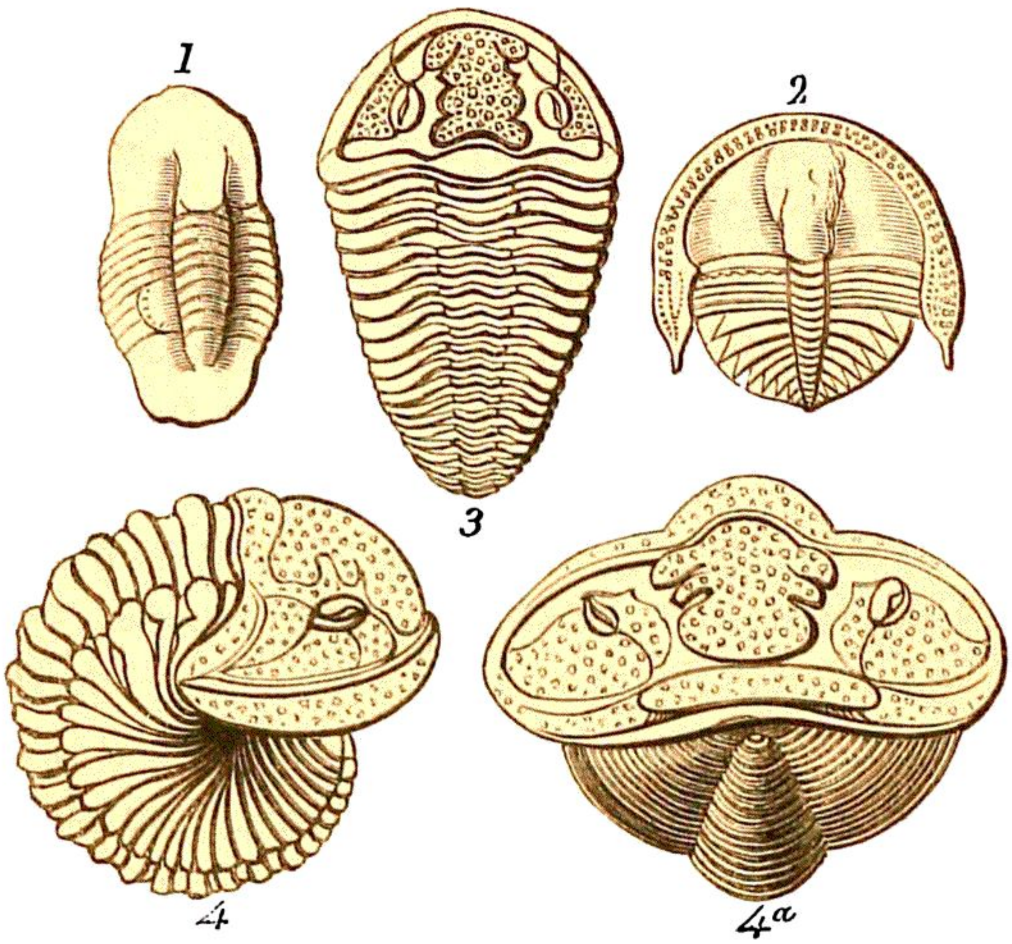
TRILOBITES.—Among the numerous petrifications which are found in the limestones in the neighbourhood of Dudley, in Staffordshire, there are certain fossil bodies which, from their extraordinary form and appearance, have for more than a hundred and fifty years been objects of great interest to the naturalist, and of wonder to the general observer, and have long been provincially termed *Dudley insects*, or *locusts*.‡ LINNEUS himself placed these fossils among the insects, and indicated their anomalous nature by the name *Entomolithus paradoxus*. The most common examples consist of a convex, oblong body, divided transversely into three principal parts, and longitudinally into three lobes,

* Mr. Prestwick on the Geology of Coalbrook Dale. Geol. Trans. Vol. V. part 3.

† Geol. Trans. Vol. V. Pl. XLI. figs. 1—4.

‡ LHYWD. Philos. Trans. for the year 1698.

by two deep, parallel furrows; from this last character the name *Trilobita*, or *Trilobites*, by which the family is distinguished among naturalists, has been derived. These fossils are the carapaces, or




LIGN. 121. TRILOBITES. *Silurian Limestones.*

Fig. 1.—ILLÆNUS PEROVALIS. (*Murch. Sil. Syst.*)
2.—TRINUCLEUS LLOYDII. (*Murch. Sil. Syst.*)
3.—CALYMENE BLUMENBACHII: the upper surface of the carapace, viewed from above. *Dudley.*
4.—CALYMENE BLUMENBACHII, coiled up, and seen in profile.
4a.—The same, seen in front.

shells, of crustaceans, belonging to an extinct family, which comprises many genera, and numerous species.

But we cannot dwell upon the history of this interesting class of organic remains, the true characters and relations of which were first scientifically considered by the distinguished French philosopher, *M. Alex. Brongniart.** Several interesting memoirs on the *Trilobites* have since been published by eminent Continental and American writers;† and much light has been thrown on the subject by the labours of Martin,‡ Parkinson,§ Stokes, Phillips,‖ König,¶ Dr. Buckland,** and Mr. Murchison.†† The beautiful illustrations, and luminous description, of the Trilobites in Dr. Buckland's Bridgewater Essay (*Bd.* p. 389, and plates 45, 46.) must have rendered the intelligent reader familiar with the most important facts relating to these extinct beings. But subsequent discoveries have thrown additional light on their structure and natural affinities; and the subject has been so ably treated by Mr. W. Macleay, in an Appendix to Mr. Murchison's excellent Memoir on Trilobites (*Sil. Syst.* p. 667.),

* Hist. Nat. Crust. Foss. "Des corps organisés fossiles nommés Trilobites, par M. Alexandre Brongniart."

† A Monograph on the Trilobites of North America, by Jacob Green, M.D. Philadelphia, 1832.

‡ Petrificata Derbiensia.

§ Organic Remains of a Former World, Vol. III.

‖ Geology of Yorkshire, and Palæozoic Fossils.

¶ Icones Foss. Sect.

** Bridgewater Essay.

†† Silurian System, chap. xlvii.

that an abstract of his observations will afford the best exposition of the present state of our knowledge relating to these organic remains.

The class *Crustacea*, as we have already stated, forms two principal groups; namely, those with eyes supported on moveable peduncles, as the Crab and Lobster, and those with the eyes fixed; to this last division belongs the extinct order of TRILOBITA. In the Trilobites the head is distinct, and without antennæ; and the feet (as supposed) are rudimentary, soft, and membranaceous: the essential characters which separate them from all other crustaceans, except *Bopyrus** (the parasite of the common prawn), according to Mr. Macleay, are the deficiency of antennæ, and of lateral posterior abdominal appendages, with the presence of evanescent feet. The *Trilobites* have been arranged in numerous genera, with names, of which a few are expressive of natural characters, but the others have reference to the obscurity that still invests some parts of the organization of these animals.†

CALYMENE BLUMENBACHII. *Lign.* 121, figs. 3, 4.—This is the Trilobite so well known as the *Dudley locust*, or *insect*. It consists of an ovate, convex, or

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* This creature is found attached near the branchiæ, and appears like a tumour on the side of the Prawn; by removing the outer pellicle the *Bopyrus* may be disclosed.

† Asaphus, *obscure;* Calymene, *concealed;* Agnostus, *unknown*, are examples.

trilobed crustaceous shell, or case, and is found either expanded, as in *Lign.* 121, fig. 3, with its under surface attached to, and blended with, the limestone (*Wond.* p. 674.); or coiled up like an *Oniscus*, or wood-louse, as in figs. 4 and 4[a]. The head is large, convex, rounded in front, with a broad border, and divided into three lobes by two longitudinal depressions. The eyes are two in number, compound, and have numerous facets; they are situated at the back of the head, remote from each other. The thoracic and abdominal portions of the carapace are deeply trilobed by two longitudinal furrows, and composed of fourteen segments; there is scarcely any vestige of a tail or post-abdominal appendage. This species is from one to four inches in length.

The structure here described may be regarded as the normal type, but numerous and important modifications prevail in the different genera.

One species of *Calymene* (*C. variolaris*) has the central lobe of the head pear-shaped, and covered with tubercles; another (*C. macropthalma*) is distinguished by its large, compound eyes, which are very protuberant, and occupy the greater portion of the sides of the head (*Bd.* pl. 46, fig. 4.).

In another genus, ASAPHUS (*Bd.* pl. 45, fig. 9.), the carapace is wide, and much depressed; the middle lobe distinct, the cephalic portion rounded in front, and terminating posteriorly in a sharp process on each side. The eyes are compound, and each contains four hundred spherical lenses, many of which remain in some examples* (*Bd.* pl. 45, fig. 10.). Some kinds of Asaphus have remarkably long, pointed, caudal appendages, or tails (*Wond.* p. 676.); Mr. Murchison describes a species in which this process is two and a half inches long. In the genus *Homalonotus* (*Wond.* p. 677.) the surface is scabrous, the thoracic portion of the carapace is but obscurely lobed, and consists of thirteen segments; the abdominal is distinct from the thoracic, and formed of nine rings; it terminates in a prolonged point. One species of Asaphus (*A. tuberculatus*, *Wond.* p. 675.) is studded with minute tubercles. In another division of Trilobites the body is contractile, and very thick, and the abdomen large and scutiform, without any segmentary divisions; the small crustacean (*Illænus perovalis*, *Murch.*) *Lign.* 121, fig. 1, will serve to illustrate these characters. Some American species belonging to this group are of a gigantic size, as, for example, the *Isotelus gigas* (of Mr. Dekay) which is eighteen inches long. In the *Isotelus*† the body is of an oval shape, and the posterior angles of the head are rounded; the thorax is composed of eight segments.

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* My cabinet contains a specimen, collected by Mrs. Allnut, with many of the lenses preserved, and numerous empty sockets, from which the lenses have fallen out.

† *Isotelus*, i.e. equal extremities.

TRINUCLEUS. *Lign.* 121, fig. 2.—This genus (established by Mr. Murchison) comprises several small forms, which are only found in the lowermost Silurian rocks of England, and occur in the equivalent deposits of Sweden, Norway, and Russia.* In the *Trinucleus*, the head is obtuse, the shield trilobed, the cephalic portion rounded, and terminating in lateral spikes, and its margin is perforated by numerous porous depressions. The abdomen is large, rounded, and composed of many segments. There are no distinct eyes.

The Trilobite called BUMASTUS (from its grape-like form) by Mr. Murchison, presents a very curious modification of the normal type. Both the head and caudal extremity are rounded, with no distinct longitudinal furrows; and the whole surface of the carapace is covered by extremely thin, apparently imbricated, lamellæ, the edges of which are undulated, and the intermediate spaces studded with minute dots. The eyes are smooth, and not granulose, as in Calymene. This genus is known in England by the name of the *Barr Trilobite*, from its occurrence in the limestone near Barr, in Staffordshire; it is sometimes five inches long, and three and a half wide.

PARADOXIDES (*Bd.* pl. 46, fig. 8.) is the name of a genus, the species of which are easily recog-

* Murch. Sil. Syst. p. 217.

nised by the ends of the lateral segments of the thorax and abdomen terminating in deflected points, which extend in spikes beyond the membrane they supported, and particularly those near the tail, which are much elongated; whereas in the other genera the lateral points of the segments are united by a membrane, which often forms a border beyond them; as, for example, in *Asaphus*. One species has a sharp, two-pronged tail (*P. bimucronatus*); and another small, beautiful Paradoxides, has four caudal prongs, or spikes (*Murch. Sil. Syst.* pl. 14, fig. 10.). The animals of this genus have the body much depressed, and the lateral lobes wider than the middle lobe: some species are of considerable size.

The genus OGYGIA (*Bd.* pl. 46, fig. 9.) is characterised by the elongated, elliptical, and depressed form of the carapace, its nearly balanced extremities, and the prolongation of the buckler, or cephalic portion, on each side, into slender spikes, distinct from the body; the thoracic and abdominal regions are divided by two deep, longitudinal furrows, into three lobes; there is also a straight, longitudinal groove, in the front of the buckler. The Trilobites of this genus occur in great abundance in the slate rocks of Angers, and some species are more than a foot in length.

A very peculiar form of Trilobite (*Brontes flabellifer*, *Ly.* II. p. 157.) is found in the Devonian strata of the Eifel and South Devonshire; the head, or cephalic region, is narrow, and has two lunated eyes; the thoracic region is trilobed and short, and composed of about ten small segments; and the abdominal very small, and bordered by segments, which radiate from the abdomen, and form a wide, fan-shaped expansion.

With regard to the under surface of the Trilobites much remains to be known. No decided indications, either of antennæ, or extremities, have been discovered. In an American specimen, Mr. Stokes, whose profound knowledge of the *Invertebrata* is well known, detected a plate,* which Mr. Macleay considers to be a *labrum*, or upper lip, resembling that of *Apus cancriformis*. This animal has a similar labrum, "and lateral influted terminations of the shelly segments of the body, with a distinctly trilobed *pygidium* (tail or caudal portion), and a prolonged tail: the feet being foliaceous, and the abdomen merely covered by a membrane."† In the upper or dorsal surface of the carapace the Trilobites approach certain *Isopoda*, particularly in the characters of the buckler and eyes. Mr. Macleay proceeds to state, that among the existing crustaceans, there are certain genera which individually possess some one or more of the characters, which have been thought peculiar to the extinct Trilobites. Thus the *Serolis* (*Bd.* pl. 45, fig. 6.),

* Geol. Trans. Vol. II. p. 208. See also Bd. pl. 45, fig. 12.

† Murch. Sil. Syst. p. 665.

and the *Bopyrus*, have a trilobed form; the female *Cymathoæ* have the coriaceous margin of the body, and in some species are without eyes, as are many of the Trilobites; while the eyes of the males of some *Cymathoæ* are composed of large facets, and are situated on the back of the head, wide apart, as in the *Calymene;* rudimentary feet, and the absence of antennæ occur in *Bopyrus;* and lastly, the *Spheroma* has an onisciform body, and the power of rolling itself up into a ball, like the Calymene (*Lign.* 121, fig. 4.). The analogy between the Bopyrus and the Barr Trilobite is so close, that if the latter had a body with thirteen equal segments, and short crustaceous feet, it would be in every essential particular a male *Bopyrus.** From the absence of eyes in the female, and their presence in the males of certain recent genera of crustaceans, it is not improbable that a similar character may have prevailed in the Trilobites, and that certain fossils referred to different genera, from the presence or absence of eyes, may have been the males and females of the same species.

The habits of the Trilobites, as deducible from this luminous exposition of their structure and affinities by Mr. Macleay, must have resembled those of the *Cymothoadæ*, some of which, like the Calymenes, coil themselves up, and are not parisitical; while their close affinity to Bopyrus, and the appa-

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* Murch. Sil. Syst. p. 667.

rent absence of distinct crustaceous feet, imply that they were to a certain degree sedentary. The flat under surface of their bodies, and the lateral coriaceous margin of several species, which is so analogous to that of the multivalve shell *Chiton*, render it probable that they adhered by a soft, articulated, under surface, to the rocks or sea-weeds. The blind species were, perhaps, sedentary; but those with highly organized eyes must, at least, have had the power of crawling in search of their food, for no truly sessile animal is provided with organs of vision, as we have seen in the Balanus (p. 519), which when free has eyes, but loses them when transformed into a permanently fixed animal. But their instruments of progression are unknown; whether they moved by means of membranaceous feet, or by the undulations of setigerous segments, like the earth-worm, or by wrinkling the under surface of the abdomen, like the Chiton, are questions yet to be determined. It is evident, from their longitudinally trilobed form, and lateral coriaceous margin, that they had the power of firmly adhering to flat surfaces; and while thus sedentary the thin but hard dorsal crustaceous shell would protect them from the attacks of their enemies. "The Trilobites, probably, like the Chitones, adhered in masses one upon another, and thus formed those conglomerations of individuals which are so remarkable in certain rocks; but it is not likely that they were parasitical, since almost all the existing parasites that adhere to other animals, have strong feet, armed at their extremities with hooks for that purpose."* From the form of the *labrum* of the mouth, discovered by Mr. Stokes, it is inferred that they were carnivorous, preying on naked mollusks, or on the annelides, with which their remains are associated.

As the compound eyes of the *Trilobites* are similar to those of existing crustaceans and insects (see *Wond.* p. 677.), the highly interesting and important fact is established, that the mutual relations of light to the eye, and of the eye to light, were the same in the remote epoch when the Trilobites flourished, as at the present time; and that the condition of the waters of the sea, and the atmosphere, and the relation of both these media to light, have undergone no change through the countless ages that have elapsed since the deposition of the Silurian strata.†

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GEOLOGICAL DISTRIBUTION OF FOSSIL CRUSTACEANS.—We have seen that the Tertiary strata contain the remains of many of the highest organized crustaceans; a few brachyurous and macrourous

* Murch. Sil. Syst. p. 669.

† See Dr. Buckland's eloquent and luminous commentary on this subject, Bd. p. 401—404.

genera appear in the Cretaceous and Oolitic formations; and several species of Cypris, and of Isopodous crustaceans whose generic affinities are undetermined, occur in the Wealden. One species of macrourous decapod has been found in the Muschelkalk of Germany. In the older formations of enormous thickness, which are composed of marine detritus, and contain countless myriads of the relics of the inhabitants of the ocean, not one species of the numerous tribes of Crabs, Lobsters, &c. has been observed. A few species of Limulus, and Trilobites, appear in the strata of the Carboniferous system, and conduct us to the grand mausoleum of these ancient beings, the Silurian formation; for no vestiges of crustaceans have been observed in the Devonian system. The geological range of the Trilobites in the subdivisions of the Silurian rocks, is thus defined by the eminent geologist who first introduced order and arrangement, and assigned definite characters, to the strata formerly known as the Transition, or *Grauwacke*, deposits.

In the Upper Silurian strata we enter upon the grand Trilobitic series. The highest zone, or Ludlow rock, contains that extraordinary form, which differs so remarkably from all others, the *Homalonotus*, (*Wond.* p. 677.); and this genus is characteristic of the Ludlow and Wenlock limestones. The *Calymene Blumenbachii* (*Lign.* 121, fig. 3.) ranges through the Ludlow and Wenlock formations, but is particularly abundant only in the lower limestones, beneath which it has not been observed. The *Asaphus caudatus* (*Wond.* p. 676.) extends from the Ludlow rock to the base of the Wenlock formation; both these Trilobites are, therefore, generally characteristic of the Upper Silurian rocks. The Wenlock formation also exclusively contains some peculiar forms, as *Calymene macropthalma*, and *C. variolaris*, *Bumastus*, and two species of *Paradoxides*. The Lower Silurian comprises three distinct genera, namely, the *Trinucleus*, (*Lign.* 121, fig. 2.) *Ogygia*, and *Agnostus*.*

In the Caradoc formation the *Trinucleus* is most characteristic. This genus (of which six species are described by Mr. Murchison) pervades the lower Silurian rocks, occurring not only in vast abundance in the Caradoc sandstone, but occasionally also in the underlying flags. In the lowermost group of the Silurian system, the Llandeilo flags, and associated schists, the *Agnostus* and *Ogygia* occur, associated with distinct species of *Asaphus*, and two or three species of *Trinucleus*. Mr. Murchison concludes his admirable summary with the remark, that "no example is yet known of a species of Trilobite, which is common in the Upper Silurian

* This is a small crustaceous body, the precise nature of which (as the name *Agnostus* implies) is unknown; it is supposed to be the young state of some crustacean, or perhaps Annelide. In Norway, it swarms in the Silurian strata.

rocks, having been found in the lower beds of the system."*

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On Collecting Fossil Crustaceans. — The Crabs, Lobsters, and other crustaceans of the argillaceous tertiary strata, are generally imbedded in masses or nodules of indurated clay and septaria. On the shore beneath the cliffs on the north of the Isle of Sheppey, specimens may be observed in the nodules that have been exposed to the action of the waves, the attrition to which they have been subjected having partially worn away the surrounding stone, and displayed the enclosed fossils. In these examples the carapace is occasionally seen on one side, and the pair of pincer-claws on the other face of the boulder ; the other feet, and the plates of the thorax, may sometimes be developed in such examples, by chiselling away the enveloping mass. In the laminated marls of the tertiary and other deposits, in which the minute crustaceans, as the *Cyprides* abound, thin slabs covered with these relics may be easily extracted.

The Chalk crustaceans, particularly those which are muricated, or beset with spines and tubercles, as the *Astacus Sussexiensis* and *A. Leachii*, (*Lign.* 116,) require considerable patience and dexterity to deve-

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* Murch. Sil. Syst. pp. 647—649.

lope successfully. The crustaceous covering of the carapace and claws adheres firmly to the chalk by the rough external coat, while the inner, smooth, glossy surface as readily separates. Hence, upon breaking a block of chalk containing portions of these crustaceans, we find one piece exhibiting a chalk cast of the claw or carapace, covered with tubercles, or papillæ, that have been moulded in the bases of the spines of the crust; and on the other portion, the crustaceous shell imbedded by its outer surface, and presenting the internal glossy lining, beset with circular depressions, which are the bases of the spines. This crust is exceedingly friable, and will flake off by a very slight touch. To obtain specimens with the external characters, it is necessary to proceed with great caution; and when indications of a crustacean is observed in a block, the chalk should be chiselled or sawn off to within half an inch of the surface of the fossil, and the remainder of the stone be cleared away, piece by piece, by means of a penknife, or graver. By this process the fossils, figured *Foss. South D.* (Pl. XXIX., XXX., XXXI.) were developed. When a fine specimen has been broken, and the shell is attached to one piece of the stone, and the cast to the other, it is possible to obtain an illustrative example of the external surface, by cementing the pieces accurately together with very thin hot glue; and, when firmly consolidated, the chalk may be removed, and the spines, tubercles, and papillæ of the crustaceous covering be developed, by the method previously described. A thin coating of mastic varnish will give durability to the crust, and improve its appearance; but the rich brown colour it possesses when first exposed, soon disappears.

The small crustaceans of the Carboniferous system, as the Limuli, often form the nuclei of clay nodules, as in the example figured *Lign.* 120, in which fig. 2 represents the nodule without any external indication of its contents; and figs. 1, and 3, the same broken, and displaying the crustacean. Traces of the legs, branchiæ, and other appendages, should be diligently sought for in fossils of this kind, for they are more likely to be detected in such specimens than in those found in limestone. It is possible that polished sections of the coiled up examples of Trilobites (*Lign.* 121, fig. 4.), would throw some light upon the nature of the hitherto undiscovered organs of locomotion and respiration, of this extinct order of Crustaceans.

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A FEW BRITISH LOCALITIES OF FOSSIL CRUSTACEANS.

Aberystwith, neighbourhood of. *Trilobites.*

Arundel, Sussex. Chalk-pits in the vicinity. *Lobsters, Craw-fish.*

Atherfield, Isle of Wight. *Cyprides* in clay (*Lign.* 119.).

Barr, Staffordshire; limeworks at Hay Head. *Trilobites*, particularly of the genus *Bumastus* (see p. 558.).

Bewdley, Shropshire. *Trilobites.*

Bolland, Yorkshire. *Trilobites.*

Burdie-house, near Edinburgh. *Cyprides* and *Eurypteri*.

Burham, near the banks of the Medway, Kent. Quarry of Mr. W. Lee, a good section of the lower Chalk: fine Crustaceans.

Coalbrook Dale. *Trilobites* and *Limuli*.

Dinley, Wilts. *Isopoda* and *Cyprides* (*Lign*. 118.).

Dover. In the lower Chalk, *Astacus Sussexiensis*, &c.

Dudley, Worcestershire. *Trilobites* in abundance.

Folkstone, Kent. In Galt: small species of Crabs (*Lign*. 115.).

Gristhorpe Bay, Yorkshire. *Astacidæ* in clay nodules (*Lign*. 117.).

Hastings, Sussex, neighbourhood of. *Cyprides*.

Hollington, near Hastings. *Cyprides*.

Hordwell Cliff, Hampshire. London Clay. *Cyprides*.

Kildare, Ireland. *Trilobites*.

Langton Green, near Tunbridge Wells. Wealden: *Cyprides* in abundance.

Lewes, Sussex. In the Chalk-pits of the vicinity: *Astacidæ*, and other Crustaceans (*Lign*. 116.).

Llandeilo, Caermarthenshire. *Trilobites*, *Trinuclei*.

Llampeter, Pembrokeshire. Remains of *Annelides*, *Nereis* (*Lign*. 114.).

Malvern Hills. *Trilobites*.

Meifod Hills, Montgomeryshire. *Trilobites*, *Trinuclei*.

Mount Pleasant, Caermarthen. *Trilobites*, *Ogygia*.

Ringmer, near Lewes. In Galt: small species of Crabs (*Lign*. 115.).

Sandown Bay, Isle of Wight. *Cyprides*, in Weald Clay.

Scarborough. *Astacidæ*, in clay nodules (*Lign*. 117.).

Steyning, Sussex. In Chalk-marl: *Lobsters*, &c.

Tyrone, Ireland. *Trilobites*.

Wenlock, neighbourhood of. *Trilobites*.

Wilmington, near Marton, Salop. *Trilobites*, *Asaphus*.

Wistanstow, Salop. Caradoc limestone: *Trilobites*, *Asaphus*.

Worthing, Sussex. Neighbouring Chalk pits. *Lobsters*, &c.

## FOSSIL INSECTS AND SPIDERS.

From the Crustaceans we pass by a natural transition to the Insects, those Articulata, in which, as Professor Owen emphatically remarks, "the highest problem of animal mechanics is solved, and the body and its appendages can be lifted from the ground and propelled through the air."* The skeleton in these animals, as in the Crustaceans, is chiefly external, and consists of a hard shell, or case, (composed of a peculiar substance, termed *chitine*,) divided into segments, and furnished with articulated, or jointed hollow extremities. The head is distinct, and has a pair of compound eyes, and of jointed antennæ. To the segments that form the thorax the legs are attached, and these consist of three pieces in the hexapods, (insects with six feet,) each supporting a pair of feet. The wings in the flying insects are attached to the middle and third thoracic segments. The legs, or articulated appendages, are hollow, as in the Crustaceans, and contain the muscles and other soft parts. The generic and other distinctions adopted by naturalists, to facilitate the study of this most numerous division of the animal kingdom, are founded on the structure and

* Hunterian Lectures, p. 192.

configuration of the antennæ and wings. The latter consist of flat membranous expansions, supported by hollow tubes or nervures; and in some orders consist of one pair, and in others of two. In burrowing insects, as the Beetle, the front pair of wings constitutes a hard case (*elytron*), which covers and protects the membranous posterior pair, when the animal is in repose, or walking. The modifications of the wings furnish the characters by which the class is divided into orders. Thus the *Coleoptera* (sheathed-wings) comprise the beetles and other burrowing insects, in which the membranous wings are folded transversely beneath the *elytra*, or wing-cases. *Neuroptera* (nerved-wings), those with two pairs of transparent reticulated wings, as the *Libellula*, or Dragon-fly. *Hymenoptera* (membranous-wings), with simply veined membranous wings, as the Bee. *Lepidoptera* (scaly-wings), having wings covered with scales, as the Butterfly. *Diptera* (two-wings), the anterior pair of wings only being the instruments for flying, and the hinder pair reduced to mere clavate appendages, as the Fly. With these few remarks on those durable parts of the structure of Insects, which their fossil remains generally present, we must quit this inviting subject, and enter upon the examination of the relics which are the immediate objects of our present inquiry.

From the enduring nature of the elytra, segments, and articulated extremities of insects; the fossil remains of animals of this class might naturally be expected to abound in lacustrine and fluviatile deposits; this, however, is not the case, and except in a few favoured localities, fossil insects are seldom met with, and rank among the most rare and interesting of the organic remains of the Secondary formations. In certain tertiary beds, as at Œningen, and Aix, in Provence, insects of numerous species and genera have been discovered; and the cream-coloured limestone of Solenhofen, among its numerous other treasures, has yielded some fine examples of this class. In the Wealden, Lias, and Carboniferous strata of England a few examples have also been observed. Dr. Buckland's account of fossil spiders, scorpions, and insects (*Bd.* pp. 405—412.), brief as it is, affords an admirable epitome of the present state of our knowledge in this department of Palæontology.

Fossil Scorpion (*Bd.* pl. 46′.).—The discovery of a fossil Scorpion in coal-shale, associated with leaves, by Count Sternberg, and of Spiders, in the limestone of Solenhofen, by Count Munster, proves the existence at a very remote period, of both these insectivorous families of *Arachnidans*, or Spiders (*Bd.* p. 405.). The fossil Scorpion was found in a block of sandy argillaceous shale, at Chomle, in Bohemia. It lies imbedded amidst the carbonized remains of leaves, and a large trifid carpolithe or seed-vessel (see *Bd.* pl. 46′.); and by a fortunate separation of the shale, the back or dorsal carapace is shown on one surface; and the thorax, with five or six legs attached, and the abdominal segments, are exposed on the other, together with a fragment of the tail of another and larger Scorpion. The head and eyes, one of the jaws with teeth, and a portion of the skin, remain (*Bd.* pl. 46, figs. 3, 4, 5, 6.). The horny covering seems to have undergone no change; it is still elastic and translucent, and consists of two layers, both retaining their texture, and structure, and exhibiting under the microscope hexagonal cells divided by strong partitions.

Fossil Spiders.—With the numerous insects preserved in the gypseous marls at Aix, of which we shall treat hereafter, Spiders are occasionally found. A beautiful example, showing the under surface of a small spider, with the papillæ of the spinning organs protruded by pressure, from the cabinet of Mrs. Murchison, is figured, *Bd.* pl. 46′, fig. 12.

Fossil Neuroptera.—Of this order, the insects of which are distinguished by their four finely reticulated membranous wings, several fossil species have been found. Some of these are referable to the family *Libellula;* insects so well known from their light and elegant figure, their beautiful and variegated colours, their large lustrous wings, and the velocity and gracefulness of their motions.

FOSSIL LIBELLULA. *Lign.* 122.—Of the highly organized family of carnivorous insects, the *Libellula*, five or six species have been discovered in the lithographic limestone of Solenhofen; a beautiful specimen from that locality is represented, *Lign.* 122,

LIGN 122. FOSSIL LIBELLULA, OR DRAGON-FLY. *Solenhofen.*

(*Drawn by Mr. Joseph Dinkel.*)

In the cabinet of the Marquess of Northampton, P.R.S.

by favour of the *Marquess of Northampton.* In this example both pairs of wings remain, but one wing is pressed down beneath the abdomen; the nervures of the wings are admirably preserved.

A few examples of the remains of this family have been found in the British strata. The wing of a *Libellula* was discovered in the Lias, near Binton, in Warwickshire, by Mr. Strickland. It is two inches and ten and a half lines in length, and eight and a half lines in its greatest breadth, being one-third larger than the wing of the largest British species.* The wing of a Dragon-fly has been found in the Wealden strata of the Vale of Wardour, associated with fragments of other insects, by the Rev. P. B. Brodie.

FOSSIL CORYDALIS. *Lign.* 124, fig. 2.—The wing of a remarkable and unique fossil Neuropterous insect was discovered by me in a nodule of iron-stone, from Coalbrook Dale, and mistaken for a leaf. The specimen consists of one wing, which, as M. Audouin first ascertained, closely resembles that of the living *Corydalis* of Carolina; see *Lign.* 124, fig. 2. The membranous structure, and the distribution of the nervures, are distinctly preserved; on the portion figured, the surface of the wing lies in relief on the stone; and on the corresponding part of the nodule, a sharp imprint remains.† I have named this fossil in honour of the eminent French savant, M. Alex. Brongniart.

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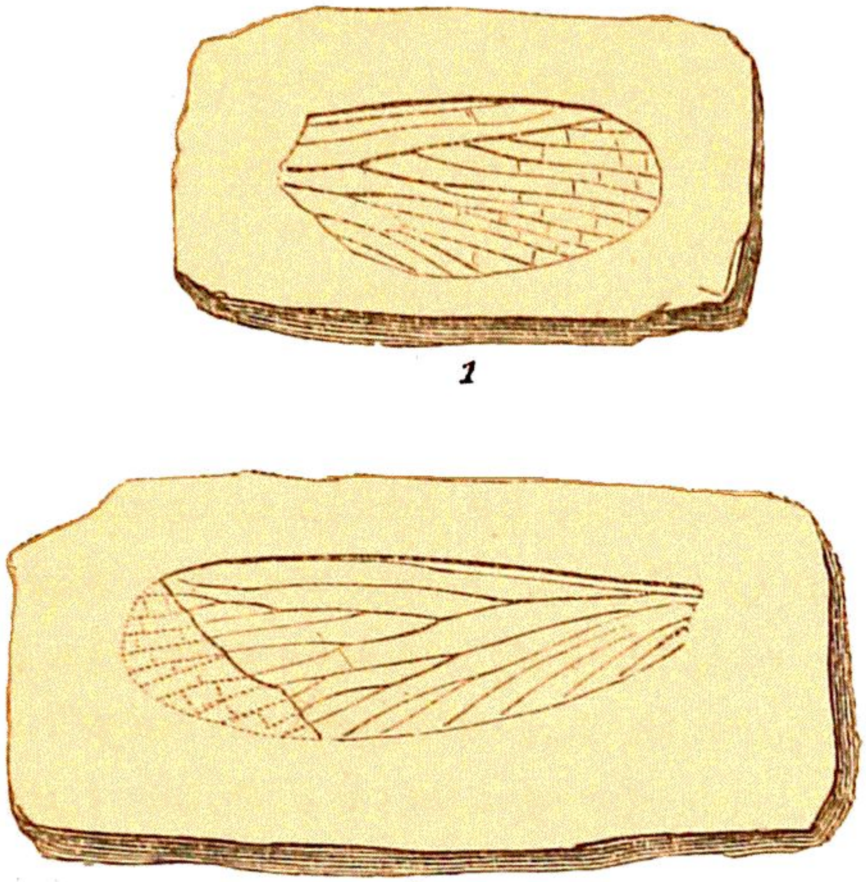
* Mr. Strickland has named this fossil, *Æstina liassina.* Mag. Nat. Hist. New Series, Vol. IV. p. 302.

† This specimen is now in the collection of the British Museum.

PANORPA LIASSICA. *Lign.* 123.—In the Lias, on the banks of the Severn, at Wainlode Cliff, Gloucestershire, a few specimens of very minute neuropterous wings have been discovered. By the kindness of Mr. Woodward, the intelligent sub-curator of the Geological Society, I subjoin accurate



LIGN. 123. WINGS OF NEUROPTEROUS INSECTS. *Lias.*

(*Drawn by S. P. Woodward, Esq.*)

Portions of the anterior wings of a species of PANORPA: × *twice.*
*Wainlode Cliff.*

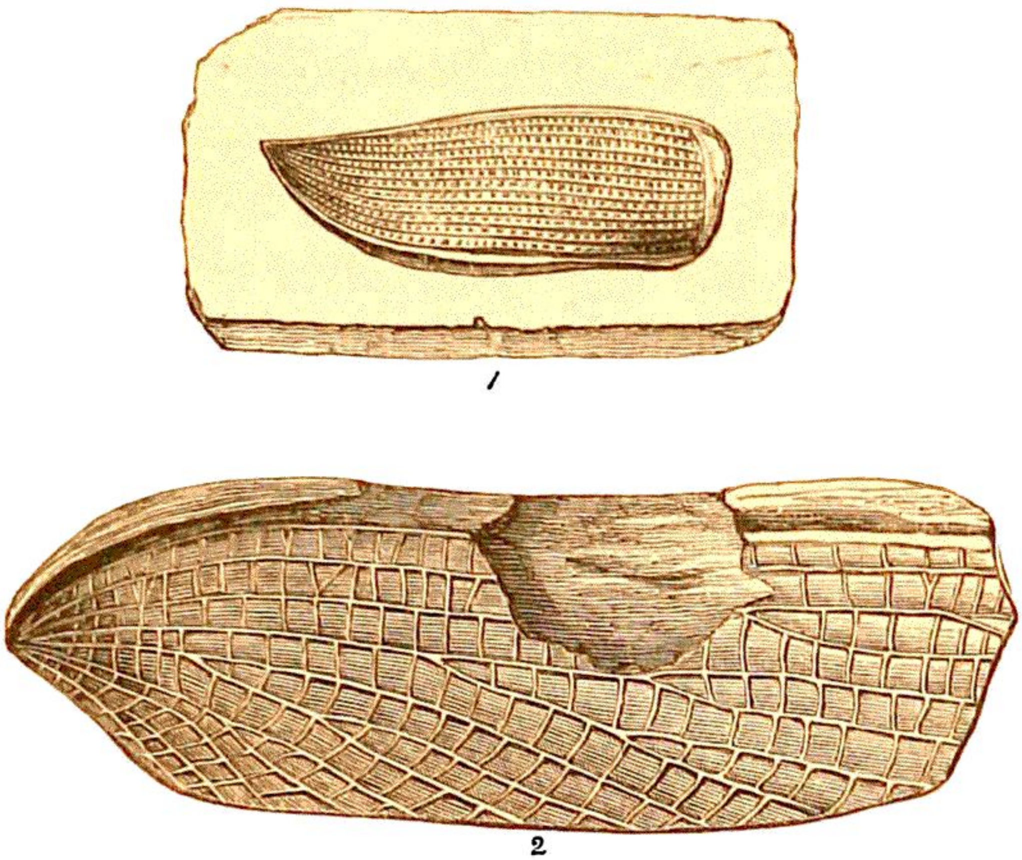
figures of two specimens from the cabinet of the Society; they are represented twice the natural size; they resemble the wings of a recent genus of Neuroptera, termed *Panorpa;* particularly *P. Germanica.* The transverse lines are not fractures, but nervures, and are faithfully copied from the originals. To the above notice of British fossil neuropterous insects, I may add that the wing of a larger species has been discovered by Dr. Buckland, in the Stonesfield slate. It most resembles the recent genus *Hemerobius*.*

FOSSIL BEETLES.—The *elytra*, or wing-cases of coleopterous insects, have long since been noticed in the oolitic slate at Stonesfield, near Oxford; a locality celebrated for the only mammalian relics hitherto discovered in the Secondary strata. The Stonesfield elytra are always found detached; in no instance, I believe, has any other part of an insect been observed, except a single leg of a *Curculio* (*Bd.* pl. 46′, fig. 10.). The specimen figured, *Lign.* 124, fig. 1, displays the usual characters of the largest species. These fossils are of a reddish-brown colour, with a finely granulated surface; there appear to be four or five species, all of which belong to *Buprestis*, a family of beetles remarkable for their splendid metallic lustre. In the Danby coal-pits, in the eastern moorlands of Yorkshire, the elytra of beetles have also been discovered, by Mr. R. C. Taylor (*Bd.* p. 78.).

A most remarkable fossil of this kind is described by Dr. Buckland; an unique specimen of *Buprestis*,

* Dr. Buckland has named this fossil, *Hemerobioïdes giganteus*. Proc. Geol. Soc. Vol. II. p. 688.

from Japan, about an inch long, *converted into chalcedony*, with the antennæ and portions of the legs finely preserved. The surface of this insect is covered with clusters of minute concentric rings of chalcedony; an appearance common in silicified



LIGN. 124. FOSSIL WINGS OF INSECTS.

(*Drawn by S. P. Woodward, Esq.*)

Fig. 1.—ELYTRON, or wing-case of BUPRESTRIS BUCKLANDI, (*Dr. Buckland*). *Stonesfield.*

2.—Wing of CORYDALIS BRONGNIARTI. (G. A. M.) *Coalbrook Dale.*

shells. Associated with this fossil, were fragments of silicified wood, bored with tubular cavities, apparently by the larvæ of insects of this family; and within these cavities was a quantity of dust produced by the boring, also converted into chalcedony (*Bd.* Vol. II. p. 78.).

Of the CURCULIO, a genus of coleoptera, distinguished by their splendid elytra, of which the *Diamond Beetle* is a familiar example, the remains of two species have been discovered in the nodular ironstone of Coalbrook Dale, by Mr. W. Anstice, and are figured and described by Dr. Buckland (*Bd.* pl. 46′, figs. 1, 2.). In one of these specimens, with the exception of the rostrum and anterior part of the head, all the essential characters of the insect are displayed; namely, the elytra, thorax, and six legs, the hindmost of which exhibits the enlarged femur, or thigh, a character peculiar to the *Curculionidæ.** The legs possess a tufted appearance, which that eminent entomologist, Mr. Curtis, conceives may have been caused by fungi, after the death of the animal, as often happens in tropical climates. In the other example the insect lies on its back, with the left side raised upwards, and exhibiting a portion of the external surface of the left elytron; there are remains of the antennæ, and indications of the proboscis and of the legs.†

Notwithstanding the most diligent research in the Wealden strata, for the remains of insects, during many years, I have not detected the slightest indi-

* Bd. II. p. 76.

† The first specimen is named by Dr. Buckland *Curculioides Ansticii*; the other *C. Prestvicii.*

cations of any fossil relics of this class. The Rev. P. B. Brodie has, however, been more successful, for in the deposits of limestone and marl which yielded the isopodous crustaceans, previously described (p. 542, *Lign.* 118.), he has discovered the remains of several orders of insects, and states that, for abundance and variety of specimens, the beds resemble the Tertiary marls of Aix and Œningen. These remains were obtained from a quarry at Dinton, about twelve miles west of Salisbury, situated in the Wealden strata of the Vale of Wardour. They consist chiefly of *Coleoptera*, with the remains of *Tricopterous* and *Homopterous* insects, &c. of several species of *Diptera*, and a wing of *Libellula*. In a quarry near the village of Stone, in Buckinghamshire, Mr. Brodie mentions that remains of insects are also found associated with scales and teeth of fishes; but neither my friend Mr. Reade, who resides near the spot, nor myself, have been so fortunate as to observe any relics of this nature; they must, therefore, be of rare occurrence, and require an experienced eye for their detection.*

I am not acquainted with any British localities of fossil insects besides those previously mentioned; for most, if not all, of the supposed relics of this

* Geol. Proc. Vol. III. pp. 134 and 781. A notice on the Discovery of the Remains of Insects in the Wealden, by the Rev. P. B. Brodie.

class described by the earlier observers, are of a questionable nature, and some are decidedly referable to Trilobites, and other crustaceans. But on the Continent, independently of the celebrated limestones of Solenhofen, to which reference has been made, there are several tertiary deposits exceedingly rich in these interesting fossils.

Fossil Insects of Aix, in Provence.—The town of Aix is situated in the lowest part of a deep valley, the immediate flanks of which are composed of a thick fresh-water formation, lying unconformably upon strata of Jura limestone. The fresh-water series consists of white and grey calcareous marls, calcareo-siliceous grits, and beds of gypsum; and the quarries formed in the latter rock have long been celebrated for the prodigious quantity of fish and plants which they contain. M. Marcel de Serres first made known the great abundance of insects in these gypseous marls, and has enumerated nearly seventy genera, chiefly of the Coleoptera, Diptera, and Hemiptera; they are mostly referable to European forms, and to existing genera. An interesting Memoir on these strata, by Mr. Murchison and Mr. Lyell,* first directed the attention of the English reader to these beautiful fossils. In *Wond.* p. 245, an epitome of this valuable communication is given, and five specimens of insects, figured *Wond.* p. 248,

* Edinburgh New Philosophical Journal for October, 1829.

will convey some idea of their forms, and perfect state of preservation.

FOSSIL INSECTS OF ŒNINGEN.—In the immediate vicinity of Œningen, near Constance, on the banks of the Rhine, there is the basin of an ancient lake, filled up with marls and limestones, presenting a fine example of a lacustrine formation, and abounding in fossil Fishes, Reptiles, Plants, Shells, Crustaceans, and Insects.* These Insects are often in an admirable state of preservation, and occur in the different stages of larva, pupa, and imago. The pupa of a *Libellula* shows the mask, insertion of the legs, and the spiracula. Some belong to genera, the species of which frequent marshy plants of the same kind as those which are found associated with the insects; and it seems probable that they fell into the lake from the plants which grew on its borders, and became enveloped in the fine mud or sediment. These fossil insects, with but few exceptions, accord with the living species now inhabiting the surrounding country.

FOSSIL LARVÆ OF PHRYGANEA (*May-fly*). *Ly.* I. p. 373.—The *Caddis-worm*, so well known to all the brethren of the angle, is the larva of the beau-

* See the elegant Memoir of Mr. Murchison on the lacustrine formation at Œningen, near Constance, Geol. Trans. Vol. III. New Series, p. 277.

tiful, delicate insect termed *Phryganea*, or May-fly, and is abundant at the bottom of fresh-water ponds and lakes; the cases, like those of the *Sabella* (p. 375, fig. 6.), are always studded over with extraneous bodies, cemented together by a glutinous secretion to the silken integument, or case, which encloses the larva. Some species are coated with pieces of stick or straw, others with minute shells, as planorbis, turbo, and the like; and when the larvæ have passed into the perfect state, their cases, or *indusiæ*, remain. Many of the Tertiary fresh-water limestones of Auvergne are almost wholly composed of the *indusiæ* of Caddis-worms, cemented together by calcareo-siliceous matter, into stone, which is employed for building, and is called indusial limestone (*Wond.* p. 261.). These limestones are associated with marls abounding in fresh-water shells and cyprides; the whole assemblage presenting all the stratigraphical and zoological characters of a lacustrine formation. "If," says Mr. Scrope,* "we consider that repeated strata, of five or six feet in thickness, almost entirely composed of these tubes, once extended over a district presenting a surface of many hundred square miles, we may have some idea of the countless myriads of minute beings which lived and died within the bosom of that ancient lake."

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* On the Geology of Central France, by G. Poulett Scrope, Esq. 1 Vol. 4to. 1827.

ON COLLECTING FOSSIL INSECTS.—The only certain localities in which the British collector can reasonably expect to obtain examples of the fossil remains of Insects, are Stonesfield, where the elytra of beetles are by no means scarce—Coalbrook Dale, in which remains of this class are sometimes, but very rarely, found in the ironstone nodules—Wainlode Cliff, in the Lias shale; but these specimens are so minute and obscure as to require an experienced eye to detect them—and Dallards, near Dinton, and Stone, near Aylesbury; the two localities of Wealden strata, in which the Rev. J. P. Brodie has discovered the insects previously described.

Should the student visit the celebrated sites of these fossils in France and Germany, namely, Aix, Œningen, Solenhofen, &c., he will have but little difficulty in obtaining an interesting series, at a moderate expense. The marls and limestones in which they occur are of a laminated character, and readily split asunder in the direction favourable for the display of the insects. In some examples the form of the insect only is seen through a thin opaque pellicle of calcareous earth, which may be removed by a penknife or graver, and the wings, elytra, antennæ, legs, &c. disclosed. Very thin mastic varnish heightens the colours of such specimens, and renders them more durable.

Gigantic Crustacean of the Devonian system.*—In the Old Red sandstone of Forfarshire, and other parts of Scotland, the remains of a very remarkable crustacean, allied to the *Eurypterus* (see p. 541.), have been long known to the quarrymen by the name of "*petrified Seraphims;*" from an imaginary resemblance of the expanded post-abdomen, to the usual representations of those angelic beings! As the specimens found in Forfarshire were, for the most part, mere scaly impressions on the stone, the nature of the original could not be determined. But many illustrative examples have been discovered at Balruddery, by Mr. Hugh Miller, and submitted to the examination of M. Agassiz, who has ascertained that they are the relics of huge crustaceans, bearing a close analogy to those found in the carboniferous strata at Burdie-house (see p. 542.). This crustacean is characterised by its angular carapace, which forms a lozenge-shaped shield; and the appendage of the post-abdomen, which, instead of being divided into segments, as in most animals of this class, is a continuous flap. The claws resemble those of the common lobster. The crustaceous covering, or shell, is ornamented on the surface with circular and elliptical markings, producing an imbricated or scaly appearance; and the imprints of this structure gave rise to the enigmatical fossils found in the sandstone of Forfarshire. Some specimens indicate a total length of four feet! †

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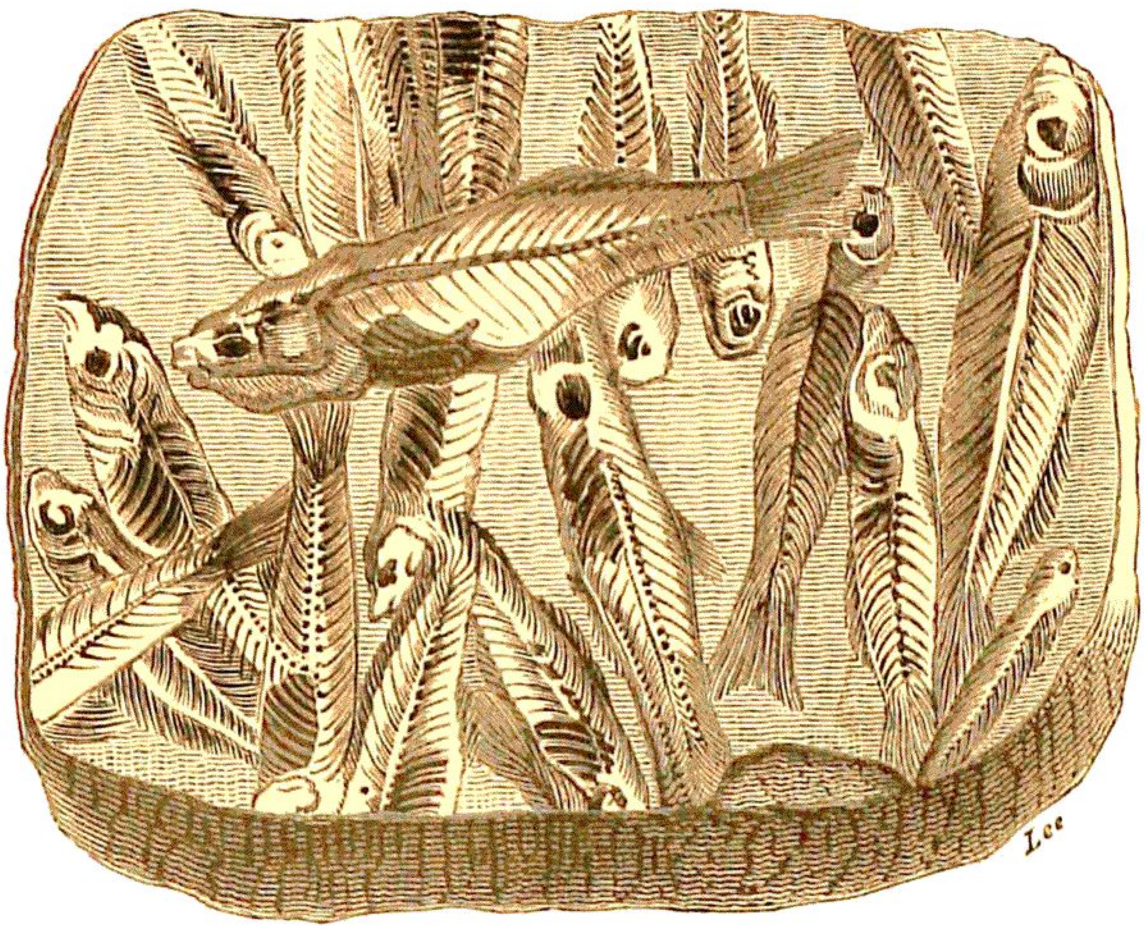
* By an inadvertence, this notice was omitted to be inserted in p. 542.

† New Walks in an Old Field, by Hugh Miller, Esq., p. 147.

SUPPLEMENTARY NOTE to p. 520, Chap. XIV.—The food of the Cirripedes is stated, in works on natural history, to consist principally of small crustaceans; but the recent observations of Mr. Hamlin Lee, have shown that the minute Infusoria and Polythalamia, largely contribute to the support of these animals. This discovery is exceedingly interesting in another point of view, for it has led to the detection of numerous recent forms, identical with those which constitute so large a proportion of the infusorial earths of Virginia; thus confirming the observations of Mr. Edwin Quekett (see p. 226.). Having obtained some living specimens of *Lepas anatifera*, Mr. Hamlin Lee submitted a portion of the pulpy contents of the stomach to a microscopical examination, and found it to consist almost wholly of polythalamia and infusoria, of the same genera and species as those which abound in the Richmond eocene deposits (see pp. 224, 232.). So perfect is the resemblance, not only of the individual forms, but also of their collocation, that a glass slide with some of the substance obtained from the Lepas, was inspected by a friend familiar with the infusorial earth, and supposed to be a specimen of that deposit; the only difference in the appearance of the recent and fossil organisms, consists in some of the former, which are but partially digested, containing colouring matter. The forms at present identified by Mr. Lee, are the following; namely, Gaillonella; Coscinodiscus, three species, one of which is decidedly *C. radiatus* (*Lign.* 48, fig. 2.); Actinocyclus (*Lign.* 48, figs. 4, 5); Dictyocha; Pyxidicula; Navicula; Bacillaria; Triceratium (*Micros. Journ.* vol. ii. pl. 12, fig. 11.). Two species of *Xanthidium* which occur in the Richmond earth; and two identical with species common in chalk flints; namely *X. tubiferum*, and *X. hirsutum*. The Polythalamia consist of several species of Rotalia, and one species of Textularia.

# CHAPTER XV.

## FOSSIL ICHTHYOLOGY; COMPRISING THE SHARKS, RAYS, AND OTHER PLACOID FISHES.



LIGN. 125. A GROUP OF FOSSIL FISHES. *Tertiary.* Aix.
LEBIAS CEPHALOTES. *Agassiz.*
(*Drawn by Miss Jane Allnutt.*)

ASCENDING from the two grand subdivisions of the animal kingdom, the *Mollusca* and the *Articulata,* we advance to the VERTEBRATA, animals distinguished from all those which have previously engaged our attention, by the possession of a bony, jointed, hollow column of support or spine, formed of bones termed *vertebræ* (*to turn*), and enclosing and protecting those strands or chords of the nervous system, called the spinal marrow; the former classes, being destitute of such a structure, have the general name of *Invertebrata.*

In the beings whose mineralized remains form the subject of our present investigation, the durable parts of the frame-work, or skeleton, are, in most instances, situated internally, and their fossil relics consist principally of the bones, or solid earthy portions of their structures, either imbedded in the rocks in their natural relative position, or in a state of dismemberment, and dispersion. In most cases the teeth, and in many the durable parts of their external integument, or skin, are also preserved, in a greater or lesser degree of integrity.

In the lowest class of *vertebrata*, the FISHES, the skin is covered with numerous pieces or scales, of a dense, durable substance, and strengthened, in some families, by the addition of osseous plates; thus constituting a flexible and almost impenetrable coat of armour, affording suitable protection to beings peculiarly exposed to external injuries, from the nature of the regions they inhabit, and the state of warfare with each other, in which they are constantly engaged. Confined to a fluid medium, they are provided with organs fitted for aquatic respiration, called *branchiæ*, or gills, and with instruments of progressive motion, termed *fins*, by which they are enabled to propel themselves through the water with great velocity. The apparatus for seizing, tearing, and crushing their prey, presents numerous and important modifications, corresponding to the habits and economy of the different genera; and their teeth offer as great variety of form and structure as those of the higher orders of animals.

The cartilaginous or osseous nature of the skeleton, and the number and position of the fins, were the characters formerly employed in the classification of Fishes; but M. Agassiz, conceiving the structure of the skin to afford a natural index to the essential modifications of organization and functions, has, with great sagacity, adopted an arrangement founded upon the form and structure of the scales; and divided the whole class into four orders, each distinguished by essential differences in the dermal (*skin*) system. To the geologist this method has proved of inestimable value; for it is simple, easy of application, and, so far as our present knowledge extends, may be relied upon as affording accurate conclusions as to the nature and relations of the originals, to which a few detached fossil scales may have belonged. Another important aid has been derived from the microscopical examination of the structure of the teeth; and a splendid work on this subject, by Professor Owen, has opened a wide field of palæontological investigation, which is yet but very partially explored.*

The living species of Fishes, exceed eight thousand, and those found in a fossil state, and determined by M. Agassiz, already amount to upwards of one thousand five hundred; while several hundreds are still undescribed; and the rapid progress of geological research is continually adding to the number: between five and six hundred British species are enumerated. In an initiatory work like the present, it will be necessary to restrict our remarks to an illustration of the mode in which the investigation of the fossil remains of the animals of this class should be conducted; and by the elucidation of a few leading principles, prepare the student for the perusal of works expressly devoted to this branch of Palæontology.†

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* ODONTOGRAPHY; or, a Treatise on the Comparative Anatomy of the Teeth; their Physiological Relations, Mode of Development, and Microscopic Structure; illustrated by upwards of 150 Plates. By Richard Owen, F.R.S. &c. London. 1840. It is much to be regretted that but two parts of this beautiful work, containing only 288 pages of letter-press, and 90 plates, have yet appeared.

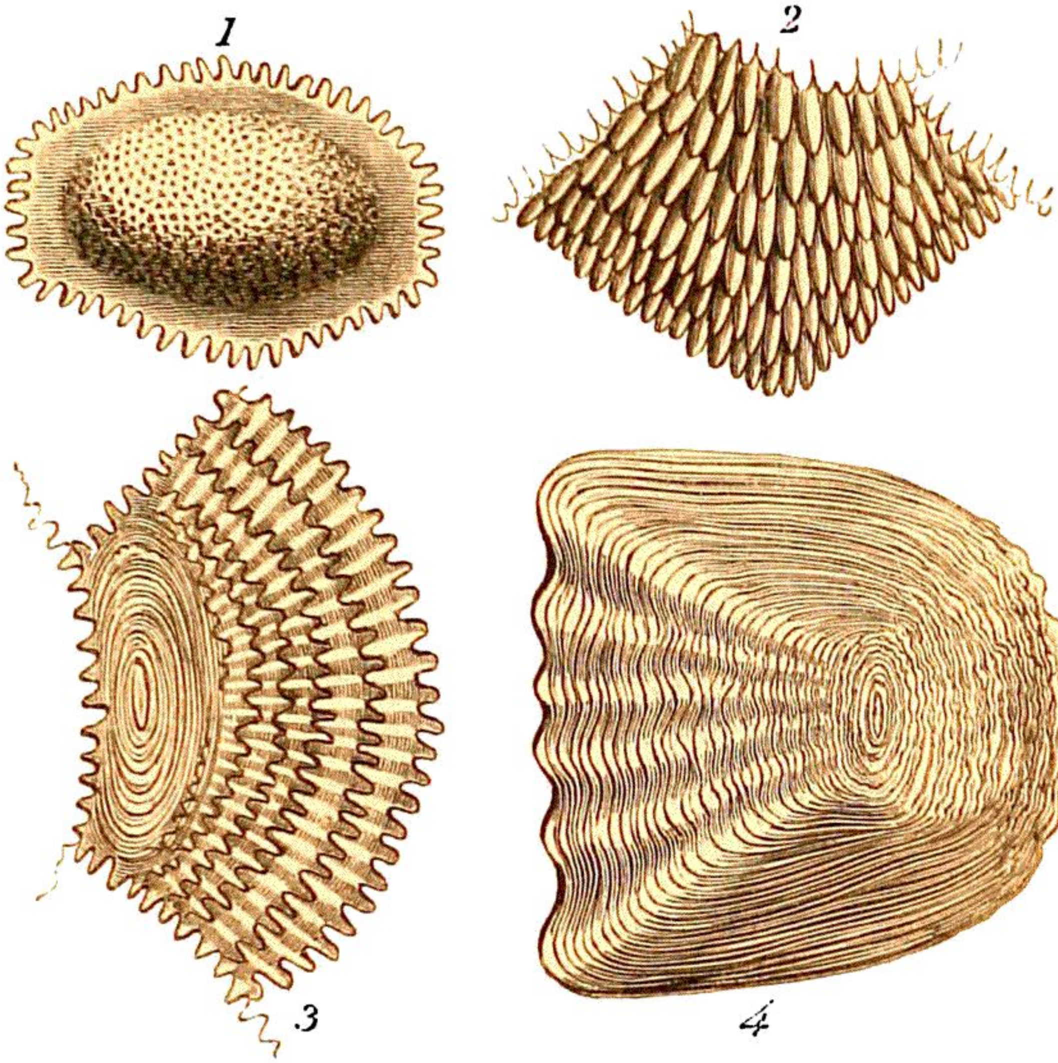
† The admirable and important work entitled "*Recherches sur les Poissons Fossiles, par Louis Agassiz,*" stands pre-eminent in this department of science; unfortunately, it is still incomplete. It is to extend to five volumes, 4to. of letter-press, and five volumes, folio, of coloured plates. It must be consulted by all who would acquire a correct view of the present state of fossil Ichthyology. *It is from this work that the commentary in the text has been chiefly derived.*

The fossil remains of fishes rank in the first class of the "Medals of Creation," for they demonstrate the existence of numerous tribes of highly organized beings in the most ancient fossiliferous strata, and the continuance of the same type of organization, variously modified, through the entire series of subsequent deposits to the present time. Each geological formation contains peculiar groups of fossil fishes, distinguished by distinct modifications of structure. Thus, according to the data at present obtained, all the osseous fishes anterior to the Chalk, belong to genera which have no representatives among existing species; and they are characterised by rhomboidal scales covered with enamel.

The state of conservation in which the fossils of this class occur, appears to have depended on the relative delicacy or firmness of the original structures, and on the nature of the deposits in which the fishes were imbedded. Thus the fossil fishes of the early formations, which are characterised by their dense integument and enamelled scales, often present the entire forms of the originals; and generally, considerable portions of the connected scales, with the fin, and other appendages. While the specimens of later deposits, which contain a large proportion of species with delicate scales, more often display the mineralized osseous skeleton, than the dermal structure. Sedimentary strata, composed of mud or fine detritus, of whatever age, have been most favourable to the preservation of the entire forms; hence we often find in the pulverulent clays and marls of the Tertiary strata, and in the Chalk of England and Westphalia, and in the fine lithographic stone of Solenhofen, fishes, perfect in form, and not only individuals, but groups, with the scales, fins, head, teeth, and even the capsule of the eye, in their natural positions. A small slab of marl from Aix, in Provence, in the collection of R. I. Murchison, Esq., contains scores of small fishes, as perfect as if recently imbedded in soft mud: a portion of this specimen is represented, *Lign.* 125; and the beautiful fish figured in the frontispiece of Vol. I. fig. 3, from near Castellamare, will serve to illustrate the state of perfection of some of the ichthyolites of the Jura limestone. In the Chalk, many of the fishes are uncompressed, the body being as perfect in form as if the original had been surrounded by soft plaster of Paris while floating in the water. But in coarse limestones and conglomerates, in other words, in materials that have been subjected to the action of the waves, and torrents, detached teeth, scales, bones, &c. constitute the principal vestiges of this class of beings.

In illustration of this branch of Palæontology, it will be expedient to consider, 1stly, the characters afforded by the scales and dermal appendages; 2dly, the teeth, or dental organs; 3dly, the osseous and cartilaginous skeletons; and lastly, apply the data thus obtained to the elucidation of some of the principal fossil genera and species.

SCALES OF FISHES.—The dermal plates or scales are composed of two substances, disposed in laminæ or plates; the one cartilaginous or horny; the other dense, and osseous, possessing the structure of bone. In most species the scales are imbricated, *i. e.* lie over each other like the tiles of a roof; the margin of a front row partly covering the series immediately behind. From this arrangement, the apparent shape of the scales is very different from their true form; the processes of attachment, and lateral angles, being concealed. The scales that are not imbricated are either very small, and imbedded in the substance of the skin so as to be imperceptible to the naked eye, as in the shagreen of *Sharks;* or are disposed in the form of bosses or scutcheons, as in the Rays; sometimes bristling equally over the surface of the body, as in the *Diodon;* and sometimes covering it like mosaic work; or forming particular series on certain regions of the body, while the other parts are garnished with different scales, as in the *Sturgeon.* There are a few genera destitute of scales. In almost all fishes there is a particular series disposed in a gently undulated line along each side of the body, and extending from the head to the tail, constituting what is termed the *lateral line;* these scales are tubular, and serve an important purpose in the economy of these animals. Every one must be aware that the body in most living fishes is constantly covered with a kind of mucus, or slime, which serves to lubricate the skin, and defend it from the action of the surrounding medium. This fluid is secreted by a mucous canal or duct, which extends along the body, and ramifies in all the bones of the head, jaws, &c.; and is distributed over the




LIGN. 126. FOSSIL SCALES OF FISHES (× ×). *Chalk. Lewes.*

Fig. 1.—Scale or plate of the *shagreen* of a SHARK.
2.—Scale of MACROPOMA MANTELLI; the exposed surface.
3.—Scale of BERYX LEWESIENSIS; the exposed surface.
4.—Scale of OSMEROIDES MANTELLI; the entire form.

surface of the head by numerous pores in the bones, and over the body, by the tubes formed by the row of scales above described.

The four orders into which this grand class of vertebrata is divided by M. Agassiz, are founded upon the peculiar structure of the scales; and are characterised as follow:—

*Order I.* PLACOID (*a broad plate*).—The skin covered irregularly with enamelled plates, sometimes of a large size, but frequently in small points, as the shagreen on the dermal integument of the *Sharks*, and the tubercles of the *Rays*. *Lign.* 126, fig. 1, a fossil *placoidian* scale from the skin of a shark, highly magnified.

*Order II.* GANOID (*splendid*, from the brilliant surface of the enamel).—The scales are of an angular form, and composed of plates of horn or bone, covered with a thick layer of enamel; their structure is identical with that of the teeth. The *Sturgeon* is an example of this order. *Lign.* 132, figs. 1, 2, 3, 4, are fossil scales of a *ganoidian* fish.

*Order III.* CTENOID (*toothed, or comb-like*).—The scales are formed of plates, which are toothed or pectinated on their posterior margin or edge, like a comb. As the plates are superimposed on each other, so that the lowermost always extend beyond the uppermost, their numerous sharp points or teeth render the scales very harsh to the touch. The *Perch* belongs to this order. *Lign.* 126, fig. 3, represents a fossil *ctenoidian* scale.

*Order IV.* CYCLOID (*a circle*).—The scales are composed of simple laminæ, or plates of bone or horn, without enamel, and have smooth borders; but their external surface is often ornamented with markings. The scales of the lateral line consist of funnels placed one within the other; the contracted part of which, applied against the disk of the scale, forms the tube through which the mucus flows. To this order belong the Mullet, Salmon, and Carp. *Lign.* 126, fig. 4, is the scale of a fossil *cycloidian* fish.

FINS OF FISHES.—As the progression of fishes through the water is principally effected by the action of the tail, they have no limbs properly so called. The instruments for balancing the body, and for assisting progression, are the fins, which are composed of numerous rays that support a membranous expansion; and the number and situation of the fins present various modifications in the different orders and genera.

The fins are named according to the situation they occupy; for example, *pectoral*, those on each side the chest, and which correspond to the anterior extremities of other vertebrata; *dorsal*, on the back; *ventral*, on the belly; *caudal*, on the tail. The rays are of two kinds; 1st, the *Spinous* rays; these consist of a single osseous piece, usually dense, and pointed, sometimes flexible and elastic, and divided longitudinally; 2d, *Soft* or *articulated rays*, which are composed of numerous small articulations or joints, dividing into branches at their extremities. Many species of fishes have four fins; others six; some but two; and in certain genera they are altogether wanting. In a fossil state the fins are often beautifully preserved; even the soft rays, in many of the Tertiary marls, and in the Chalk, are found entire, and attached to the body in their natural situation. The large, strong, spinous, rays of the dorsal fins of the cartilaginous fishes, as the *Sharks* and *Rays*, are generally found detached, or connected only with a few vertebræ; but they are so abundant in some of the Secondary deposits, and in numerous instances are the only vestiges of extinct species and genera, that they possess great geological interest; they are distinguished by the term *Ichthyodorulites* (*fossil dorsal-rays of fish*), under which head they will hereafter be described (see *Lign.* 127.). The first ray in the dorsal fin of some fishes, is protected in front by a double row of enamelled scales, and these often occur in a fossil state (see *Lign.* 132, fig. 5.).

Teeth of Fishes.—Of all the durable parts of animals which occur in the mineral kingdom, the teeth of fishes present by far the most numerous, varied, and striking modifications of form, structure, composition, mode of arrangement, and attachment; and yet these dental organs, separately considered, do not in many instances, either in their structure or mode of implantation, afford characters by which the natural affinities of the original can be satisfactorily ascertained; and without the aid of other parts of the skeleton, it is often impossible to determine whether an unknown form of tooth belonged to an animal of the class of Fishes or of Reptiles. Although the modifications of form are almost innumerable, they are referable to four principal types; namely, the conical, the flattened, the prismatic, and the cylindrical.*

* The beautiful and highly philosophical work of Professor Owen, "Odontography," should be consulted by those who

The conical teeth are extremely variable in size and form; some are slender, almost invisible points, distributed like the pile of velvet (*villous-teeth*), or set like the hairs of a brush (*brush-teeth*), or long, slender bristles, or barbed at the point; others are obtuse; and many are long and striated at the base, and closely resemble the teeth of certain reptiles. The depressed teeth are equally diversified; some have the grinding surface smooth; others, deeply grooved; in some it is flat; in others convex. In form they are either lozenge-shaped, elliptical, square, oblong, semilunar, &c. The cylindrical teeth are hemispherical, or flattened; in some fishes they are short and thick; in others slender, and support an obtuse, conical crown. The prismatic form is equally modified; from the compressed, sharp, lanceolate, cutting teeth, to the strong, triangular, three-pointed dentary organs.

The mode of arrangement and attachment of the teeth, is as diversified as their forms. In some species all the teeth are of one type, and disposed in somewhat of a serial order on both sides of the jaws; but in a large proportion of fishes there are several kinds of teeth, which are implanted not only in the jaws, properly so called, but on the bones which form the cavity of the mouth, the arches of the palate, tongue, &c.; and it is peculiar to the present class

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would thoroughly comprehend this most interesting department of science.

of vertebrata to present examples of teeth developed in the median line (*along the middle*) of the mouth, as in certain species of Rays; or crossing the symphysis (the *front line of union* of the two sides) of the lower jaw, as in *Myliobates** (see *Lign.* 131, fig. 2.). In some species the teeth are implanted in sockets, to which they are attached only by the soft parts, as in the rostral teeth of the *Saw-fish;* some have hollow bases, supported upon bony prominences, which rise from the base of the socket; as in several fossil teeth from the Chalk. "But by far the most common mode of attachment is by a continuous ossification between the dental pulp and the jaw,"† the teeth being thus anchylosed to the bone. In the Sharks the osseous bases of the teeth are attached, by a ligamentous substance, to the tough, dense crust, which covers the cartilaginous jaws; the teeth of these fishes are therefore generally found detached in a fossil state, in consequence of the decomposition of this substance.

The teeth are composed of a dense, osseous material, of a tubular structure, termed *dentine;* which, in many species, forms on the external surface of the tooth a layer of firmer texture, with a glossy surface, resembling enamel. The essential character of their organization is to have a pulp or medullary cavity, or cavities, filled with a plexus of blood-vessels and nerves, from which the minute tubes composing the

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* Odontography, p. 5. † Op. cit. p. 6.

dentine radiate. The differences observable in the size, mode of ramification, and distribution of the medullary cavities or canals, and the *calcigerous tubes,** as revealed by microscopic exploration, constitute important distinctive characters; particularly in the examination of the fossil teeth of extinct fishes. Plate VI. figs. 1, 2, represent the structure of the teeth of two common fossil species of the Shark family, from the Chalk. In some teeth the dentine is traversed by equidistant, parallel, medullary canals; in others, these channels frequently subdivide, and their branches anastomose with each other. In some the medullary canals form a reticulated, or net-like structure in the dentine, the meshes of which are occupied by calcigerous tubes, and cells; often producing a dendritical appearance, as in the tooth of a fossil fish named *Dendrodus* (by Prof. Owen), a portion of which is represented in Plate VI. fig. 8. "In the highest type of structure, the dentine consists of a simple medullary cavity or canal, and a single system of calcigerous tubes, which radiate from the central or sub-central pulp-cavity, at right angles to the periphery of the tooth,"† as in the teeth of the extinct Sauroid (*lizard-like*) fishes. A continued succession of

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* *Calcigerous tubes;* so named because they are composed of *calx*, or lime.

† See ODONTOGRAPHY, p. 10. *et seq.* for a full elucidation of the structure of the teeth of fishes.

teeth takes place during the life of the fish, and we often find in fossil specimens, a series of successional teeth, beneath the row in use; as in the fragment of a jaw of *Lepidotus*, from Tilgate Forest, *Lign.* 133.

SKELETONS OF FISHES.—The skeletons of the animals of this class, differ so remarkably in their relative degree of firmness and elasticity, in consequence of peculiar modifications of their constituent substance, as to form two grand divisions; one of which is termed the *osseous*, the other the *cartilaginous*. The essential difference in the skeletons of these two groups, consists in the presence or absence of earthy matter (*phosphate of lime*) in the materials of which they are constructed. In the cartilaginous fishes, the skeleton is homogeneous and transparent; but in some species, the skin has dense calcareous particles or plates on the skin, as in the *Rays;* and in others, the head and body are protected by osseous scutcheons, as in the *Sturgeon*. There is also an intermediate group of fishes, termed the *fibro-cartilaginous*, in which the skeleton contains phosphate of lime, but in a much less proportion than in the true osseous fishes. In some genera, certain portions of the skeleton, as the bodies of the vertebræ, are cartilaginous, while the spinous processes, ribs, &c. are osseous; these characters are of considerable importance in the investigation of the fossil remains of fishes, as we shall hereafter have occasion to demonstrate.

The skeleton consists of the *cranium* or skull, which is composed of numerous bones; the jaws, and bones of the tongue; the osseous frame-work of the organs of respiration, consisting of the bones, rays, and arches that support the gills, and the *opercula*, or covers which close over the branchial apertures; and of the vertebral column, formed of numerous dorsal and caudal vertebræ, with the ribs, and other appendages; there are no proper cervical vertebræ, or spinal bones of the neck.

The branchial arches are in general four, or five, on each side, and are attached above to the cranium, and below to a chain of small bones, by which they are connected with the *os hyoides*, or bone of the tongue. The opercular bones that compose the cover or lid of the opening of the gills, consist of three pieces on each side, and are distinguished by the names, *opercular*, *pre-opercular*, and *sub-opercular*, according to the situations which they respectively occupy.

The *vertebræ* are double hollow cones, not unlike an hour-glass in form; the interval between two of these bones is filled up, in the living state, by a gelatinous fluid. Along the upper part of each vertebra, there is an annular cavity, which in the united vertebral column forms a canal for the spinal marrow; the posterior dorsal and caudal vertebræ have also a channel below, for the passage of the large blood-vessels.

There are likewise bones analogous to some of those which enter into the composition of the extremities, chest or thorax, and pelvis, of the higher vertebrata; but which it is not necessary for our present purpose to describe.

Of the organs of vision some remains also occur in the mineral kingdom. The sclerotic coat, or capsule of the eye, being bony in fishes, is often preserved; and in several chalk specimens I have found it occupying the orbit.

In addition to those durable parts of fishes, already mentioned, as likely to be met with in a fossil state, the bones called *otolithes* (ear-stones) must be enumerated. These calcareous bodies are found in the membraneous labyrinth of the organs of hearing; and although more or less developed in the ear-bulb of all animals, they are larger and of more definite forms in the higher osseous and cartilaginous fishes. The *otolithes* are supposed to assist in communicating more vivid impressions of sounds to the extremities of the auditory nerves; they are stony in most aquatic animals, and friable or pulverulent in those that live on land. Smooth, oblong otolithes are not uncommon in the Crag deposits of Norfolk and Suffolk.

Tails of Fishes.—The tail, as we have previously mentioned, is the chief instrument of progressive motion in these animals; it assumes two principal modifications. In the greater number of the existing species, the vertebral column terminates in a triangular plate of bone, to which the caudal fin is attached symmetrically; and its figure is either rounded, or divided into two equal lobes or branches; these tails are termed *homocercal*, i.e.

even-tail (*Ly.* II. p. 99.). In the second modification, the vertebral column, towards its extremity, diverges from a straight line, and rises up, and is prolonged into the upper lobe of the tail; the caudal fin appearing like a rudder, and the lower lobe being proportionably very feeble and small; as in the Shark and Dog-fish (*Ly.* II. p. 99): this form of tail is called *heterocercal*, i. e. unequal-tail. But few of the existing fishes have this condition of the caudal fin, while it is found in all the fossil species that occur in the ancient secondary strata; namely, the Magnesian limestone, and antecedent deposits. The rounded, and equally-bilobed or homocercal tails, are seen in the fishes from the Chalk, *Wond.* p. 334; and the rudder-like, or heterocercal tail, is shown in the fish from the Carboniferous strata, *Wond.* p. 681.

From this brief summary of the essential characters of those durable parts of the organization of fishes, which most frequently occur in a fossil state, we pass to the investigation of some illustrative examples of this class of organic remains. But before describing any entire specimens, it will be expedient to notice the separate fins, and teeth, which abound in many deposits; in some instances occurring in connexion with other parts of the skeleton, but very generally detached, and yielding the only evidence of the existence of numerous extinct species and genera. The greater part belong to the first order—the Placoidians (*Poiss. Foss.* Tom. III.), and to the families of *Sharks* and *Rays*. The osseous dorsal rays of cartilaginous fishes (named *Ichthyodorulites*, by Dr. Buckland and Sir H. De la Beche), first demand our notice.

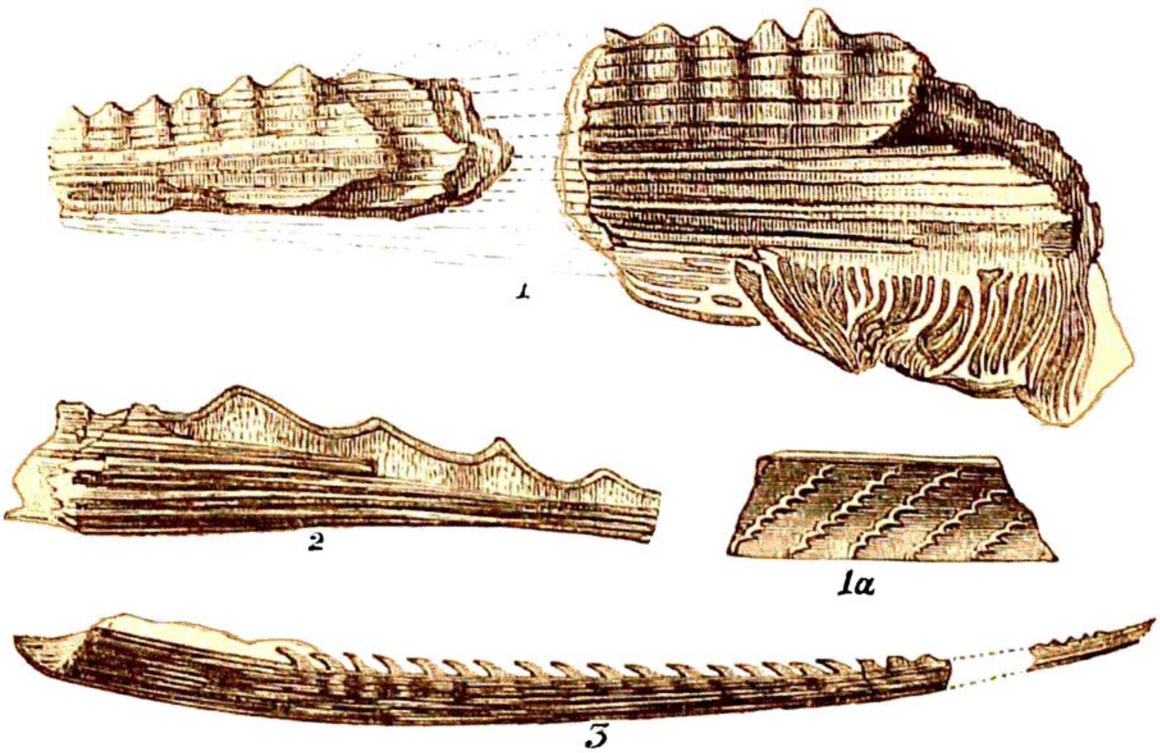
ICHTHYODORULITES. *Lign.* 126.—This name is applied to the fossil spines, or rays, of the dorsal fins, of which numerous species occur in the Secondary and Tertiary deposits; they belong, for the most part, to extinct cartilaginous fishes. In the osseous tribes the dorsal spines have at their base two articular processes, by which they are united to the osselets that support them, as in the *Silurus*; but in the cartilaginous, they have no articulations at the base, and terminate in an obtuse point, which is implanted in the flesh; the posterior margin is grooved almost to the upper extremity. They are of a fibrous, osseous texture. The common *Spinax*, or Dog-fish (*Acanthias vulgaris*), has a spine of this kind in the front of each dorsal fin. The rays of the Sharks are compressed, and some have rows of teeth on the posterior margin. In the genus *Cestracion* (Port-Jackson Shark), the rays are strong, triangular, straight, pointed, rounded in front, flat at the posterior face, and widest at the base. In the RAYS the dorsal spines are flattened or depressed. The greater part of the fossil species of the Secondary formations belongs to the numerous family of Sharks.* These spines are generally

* Poiss. Foss. Tom. III.

capable of being elevated and depressed, and not only serve the purpose of defence, but, in many species, give support and protection to the soft rays of the fin; forming, as it were, a moveable mast, by which the sail can be spread out or lowered at pleasure.

The fossil rays occur in all the sedimentary deposits, peculiar forms appearing in the several formations; and each geological epoch, according to M. Agassiz, is characterised by particular species.

In illustration of this subject, I would first direct the attention of the reader to the beautiful fossil, figured *Lign.* 127, fig. 1, which was discovered in the Chalk near Lewes, and is figured, of the natural size, *Foss. South D.* Tab. XXXIX. This ray, or spine, belongs to some of the cartilaginous fishes (*Ptychodus*), whose teeth are so abundant in the Chalk, and will presently be described. It is composed of fourteen thick, flat, osseous rods, or strands, intimately united together, with longitudinal furrows or sutures on the surface. The anterior margin is embossed, and the projections form on the sides wide, rounded ribs, and transverse depressions. Towards the base of the posterior part, there are large, osseous fibres, inserted vertically and obliquely, which appear to have been processes of attachment. The rods, or plates, are parallel with the posterior margin, and each terminates in a rounded extremity, or boss, on the front edge of the fin. This ray is wider at its base than at the superior part; the anterior margin is oblique, and the posterior straight. The surface, where entire, is covered with a dense osseous substance, which is finely engrailed.*




LIGN. 127. DORSAL RAYS OF SHARKS. *Sussex.*

Fig. 1.—PTYCHODUS SPECTABILIS: $\frac{1}{5}$ *nat. Chalk. Lewes.*
1 *a.*—Portion of a RAY, with oblique serrated sutures. *Chalk. Lewes.*
2.—PTYCHODUS GIBBERULUS: $\frac{}{5}$ *nat. Chalk. Lewes.*
3.—HYBODUS SUBCARINATUS: *nat. Tilgate Forest.*

A smaller species of Ichthyodorulite, found in the same quarry, is distinguished from the former

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* This specimen is figured in *Poiss. Foss.*; but it is represented too short, from the two portions being drawn as if they were connected, instead of allowing an interval between them, as in *Lign.* 127.

(*Ptychodus spectabilis*), by its osseous plates contracting towards their extremities, and terminating more suddenly on the front margin, producing gibbosities less acute, and more distant, than in *P. spectabilis*; this species is named *P. gibberulus*: see *Lign.* 127, fig. 2.* The first species must have belonged to a fish of large size, for some examples, when entire, would exceed two feet in length. The bony plates of these fins are occasionally found lying in irregular groups in the Chalk, as if the fin had partially decomposed, and the plates separated. In one example, the rays are split asunder by a piece of bone, apparently a portion of a long, pointed tooth, firmly impacted between them; as if the fish had been seized by some enemy, and had escaped, with the tooth of its adversary in its fin.

In the fragment of an Ichthyodorulite from the Lewes Chalk, a remarkable structure is displayed; the osseous plates are united laterally by smooth, longitudinal lines, as in those above described; but they are also traversed by numerous oblique, finely-serrated sutures: see *Lign.* 127, fig. 1 *a*.

The Chalk contains rays of other species of *Ptychodus*, as well as of some allied genera. Of these, the most remarkable are smooth, arched, pointed spines, having a shallow posterior groove,

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* This fossil is figured of the natural size, Foss. South D. Pl. XL. fig. 3.

with an enamelled surface, marked with fine longitudinal striæ. These belong to the genus Acanthias (*Dog-fish*), and are larger, and more arched, than in the recent species. One species is named *Acanthias major*: see *Foss. South D.* Tab. XXXIII. fig. 5.*

It may be necessary to remark, that the fins first described have been referred to the fishes which yielded the large grooved teeth so common in the Chalk (see Pl. VI. fig. 2.), in consequence of their affinity to existing species, which have similar fins and teeth; and from the circumstance that the Sharks of the genus *Lamna*, whose teeth also abound in the Chalk, have no dorsal rays of this kind: still the proof of identity remains to be discovered. In one specimen only have I observed indications of any other part of the skeleton; it is a spine of *Acanthias major*, the base of which rests on several dorsal vertebræ (*Foss. South D.* Tab. XXXIII.). My collection also contained the dorsal ray of an extinct species of *Chimæra* (*Poiss. Foss.* III. p. 65.).

Hybodus subcarinatus. *Lign.* 127, fig. 3.—The fishes of another extinct genus of Sharks, termed *Hybodus*, from the gibbous form of the teeth, were also provided with dorsal spines, which may be readily distinguished from the preceding. These

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* All these spines were discovered by me in Bridgwick Chalk-pit, near Lewes. This quarry is no longer worked.

Ichthyodorulites are generally long, very slightly arched, terminating in a point at the extremity, and having the base, which was implanted in the flesh, much prolonged, being sometimes equal to one-third of the entire length, and deeply grooved. The surface is marked with strong longitudinal ridges, parallel with the anterior margin, which is rounded, and laterally compressed. The posterior edge, which is more or less flat, has, towards the base, two rows of sharp arched teeth which gradually approach each other, and blend into one line on the upper part of the ray. There are numerous species of this genus in the Oolite and Lias. I have found one species in the Chalk, and a few in the Wealden. The small Ray figured *Lign.* 127, fig. 3, is from Tilgate Forest, and displays the usual characters of these fossils. From specimens discovered in the Lias, associated with the teeth, it appears that the *Hybodus* had two dorsal fins, each furnished with rays, as in the recent Dog-fish.

The microscopic structure of these rays is stated by M. Agassiz to resemble that of the teeth: in some there is a pulp-cavity, which occupies the centre of the spine, and is surrounded by dentine, in which the calcigerous tubes radiate direct to the surface; the external enamel is a layer of dentine, in which the medullary canals are wanting.

In the strata below the Lias there are numerous Ichthyodorulites, some of a large size, belonging to cartilaginous fishes, chiefly of the Shark family, and of extinct species, not observed in more recent deposits. Thus there are several species of dorsal rays that are wide at the base, and bent backwards, with the posterior margin destitute of teeth (named *Onchus*, from their hooked form), in the Carboniferous, Devonian, and Silurian formations; also immense compressed spines, having small teeth on the posterior margin, and the surface covered with longitudinal striæ, and finely toothed, transversely; hence termed *Ctenacanthus*, or pectinated-spine (*Murch. Sil. Syst.* p. 596.).

Some Ichthyodorulites have the surface richly ornamented with stellular tubercles (*Asteracanthus*, or starry-spine); and there are very large spines of this kind in the Oolite and Kimmeridge Clay.*

The Ichthyodorulites of the *Rays* have no cavity like those of the Sharks, and are of a depressed form, and more or less flattened; they are armed with teeth along their exterior margins, and not on the posterior edge, as in the latter family.

Fossil Teeth of Fishes.—From the durable nature, and striking appearance of many of the fossil teeth of fishes, and their prodigious numbers in some deposits, they are familiar objects to the collector. By far the largest proportion of the

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* Many of these fossils were first figured and described by Dr. Buckland and Sir H. De la Beche. For particular information on Ichthyodorulites, *Poiss. Foss.* Tom. III. chap. i. should be consulted. About seventy species are enumerated.

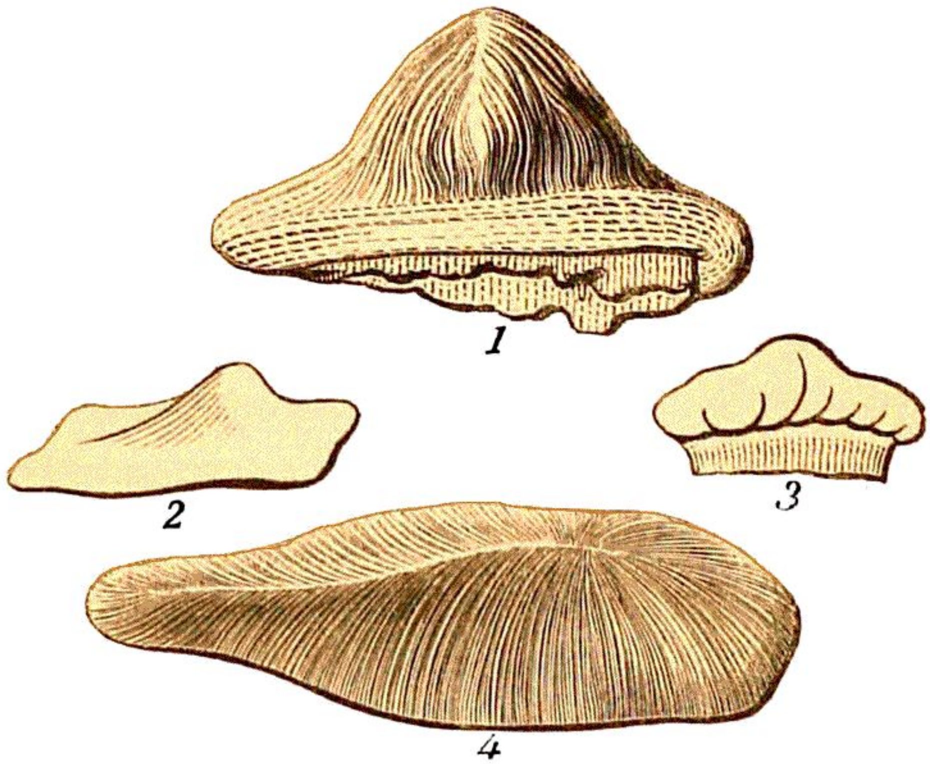
detached teeth belongs to various species and genera of that most numerous, and widely distributed family of voracious fishes, the SHARKS. In the Tertiary strata, teeth of this kind occur of a very large size; in the Chalk many species abound, particularly of the lanceolate and compressed forms, and of the rugous mammillated teeth, commonly termed *palates*. As we pass to the more ancient formations, teeth of a different form prevail; and those which approach the recent types, are either very rare, or altogether absent. We will select some examples of the different genera in illustration of this subject; our previous observations on the form and structure of the recent teeth, render but few introductory remarks necessary.

FOSSIL TEETH OF SHARKS.—The fishes of the families of Sharks and Rays, belong to the *Placoid* order, their scales consisting of enamelled plates and tubercles, forming a *shagreen* in the former, and appearing as spines and bosses, irregularly disposed, in the dermal integument of the latter. Notwithstanding the diversity in appearance of the teeth of Sharks, they all possess one essential character of structure, namely, a base, or osseous root of variable form, which is implanted in the integuments; and a crown, or external portion, which projects into the mouth, is covered with enamel, or compact dentine, and assumes numerous modifications, by which the fossil genera are characterised. These teeth are never imbedded in sockets, nor united to the dentary margins of the jaws; they only adhere to the integuments of the mouth, and the covering of the maxillæ; they possess, in most of the Sharks, great mobility. They are generally disposed in rows; the anterior ones, being first used, fall out, and are replaced by those on the inner series. New teeth are also continually formed behind those which exist, and advance successively towards the anterior rows as the latter are shed, and in their turn occupy the front rank. An examination of the fossil and recent teeth of Sharks and Rays, proves that the prevailing existing generic types have but few, if any, representatives in the fossils, except in those which belong to the Tertiary and Cretaceous formations; while the genera that appear isolated, as it were, in the present seas, have numerous analogous genera in the secondary strata.

The fossil teeth of this family may be divided into two grand divisions; namely, those which are more or less of a polygonal, obtusely conical, or depressed form, having a tesselated arrangement in the mouth; and those of a triangular, lanceolate shape, with cutting, or serrated edges, disposed in a series of rows on the jaws. The teeth of the first group have most analogy to those of the living genus CESTRACION (*Port-Jackson Shark*); the second to the SHARKS, commonly so called.

The *Cestracionts* are the only living representatives of a numerous family of squaloid fishes of a peculiar type, whose remains occur even in the earliest fossiliferous deposits; they inhabit the seas of New Holland and the southern coasts of China. The jaws of the Cestracionts are relatively very large, and are armed with numerous rows of teeth, essentially of two kinds; those situated anteriorly, or towards the front of the mouth, being adapted for seizing and retaining the food, and the posterior ones for crushing and bruising. The prehensile teeth are sharp, angular, and pointed; the others are obtuse, polygonal, enamelled, and disposed in oblique rows along the margins and inner surface of both jaws: there are sometimes sixty in each jaw (see *Bd.* II. pl. 27[d.] fig. A.). Fossil teeth of this type are exceedingly numerous in the Chalk, Lias, &c., but are very seldom found in juxtaposition; the decomposition of the cartilaginous integuments in which they were imbedded, having, in most examples, occasioned their displacement and dispersion; specimens, however, are occasionally discovered, in which numerous teeth, of various sizes, are disposed in mosaic, in their natural relative positions.

ACRODUS NOBILIS. *Lign.* 128, fig. 4.—In the Lias and Oolite, oblong enamelled teeth, having the surface of the crown covered with fine radiating grooves and striæ, are known in many parts of England, by the name of the "*Leech palate*," from a fancied resemblance to a contracted leech. They belong to an extinct genus (termed *Acrodus*), closely allied to the *Cestracionts*. The base of the tooth is in the form of a parallelogram inclined on its inner side; and the crown is enamelled, and covered with transverse grooves, which diverge from a longitudinal furrow. These teeth were inserted along the jaws in oblique series, their longitudinal direction corresponding with that of the bones which



LIGN. 128. FOSSIL TEETH OF SHARKS.

Fig. 1.—PTYCHODUS MORTONI. (G. A. M.) *Cret. New Jersey.*
2.—PSAMMODUS CINCTUS. (*Ag.*) *Mt. L. Bristol.*
3.—ORODUS CINCTUS. (*Ag.*) *Mt. L. Bristol.*
4.—ACRODUS NOBILIS. *Lias. Lyme Regis.*

support them; in their natural position, the extremity of a hind tooth was enclosed between two anterior teeth. A beautiful group is figured *Bd.* II. pl. 27[e.*]

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* The microscopical structure of the teeth of *Acrodus*, is exquisitely shown in Odontography, pl. 14, 15; and presents a beautiful illustration of the relation of dentine to bone.

PTYCHODUS (*rugous-tooth*). Pl. VI. fig. 2; *Lign.* 128, and *Lign.* 130.—In the White Chalk there are fossil teeth, known by the name of "*palates*," which occur in great numbers in almost every quarry, and belong to several species of an extinct genus (*Ptychodus*) of Cestracionts. A common species is figured Plate VI. fig. 2: and microscopic views of vertical and transverse sections, as seen by transmitted light, are shown in figs. $2^b$, $2^c$. Groups of these teeth, somewhat naturally arranged, and varying in size and form, according to the situations they occupied in the jaws, are occasionally found: one specimen in my collection contained more than 120 teeth. But in general they occur singly, and in a very perfect state; their osseous base and enamelled crown being entire. The spines previously described (p. 607.), are sometimes found with the teeth, and belong to the same genus. These teeth are of an angular form, and more or less square; the crown is wide, and higher than the root, which is obtuse, truncated, and depressed in the centre; but the enamelled part of the tooth is expanded at the edges, and rises in the middle into a flattened or slightly convex mammillary projection, which is covered by large, acute, transverse, parallel ridges. The borders are granulated, and the sides of the projection marked with deep vertical plicæ or folds; this description particularly applies to the species *P. polygurus*, figured in Plate VI. Dr. Buckland has represented a fine group of these teeth, *Bd.* II. pl. 27[f]. Another very common species (*P. decurrens*) is distinguished from the former by the connexion between the large furrows on the crown, and the granulations on the expanded border, which diverge from the outer edge of the large folds to the margin of the enamel.

A species of Ptychodus occurs in the arenaceous strata of the Chalk formation, in New Jersey, which possesses the essential characters of the European fossils, but differs from them in its configuration. The only specimen in England is figured *Lign.* 128, fig. 1. The enamelled crown forms a conical projection, and is covered with large inosculating fibres or ridges, which radiate from the summit towards the margin.*

The microscopic structure of the teeth of the Ptychodus presents the same congeries of medullary and calcigerous tubes as that of the recent Cestracion (see Plate VI. figs. $2^b$, $2^c$.): but the splendid plates of Professor Owen should be inspected, to obtain a correct idea of the beautiful and complicated structure of these fossil remains.†

Psammodus (*sandy-tooth*). Pl. VI. fig. 1; *Lign.* 128, fig. 2.—This genus of extinct Cestracionts comprises those teeth whose surface is neither plated,

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* I have named it *P. Mortoni*, after the eminent American physician, Dr. George Morton, of Philadelphia, by whom it was discovered.

† Odontography, pl. 18, 19.

grooved, nor reticulated. They are generally flat or slightly convex, and of a square or oblong form, with a smooth surface, which has the appearance of fine sand, from being uniformly covered with minute pores. This is produced by the structure of the crown of the tooth, which, like that of the Cestracion, is formed of very small vertical tubes; the base is osseous, and as large as the crown. The forms of two species are shown in *Lign.* 128, fig. 2, and Pl. VI. fig. 1[a]. A magnified vertical section of the crown, displaying the medullary canals, and radiating calcigerous tubes, is represented Pl. VI. fig. 1[b], and a transverse section, fig. 1[c]; they are thin slices of a tooth, *P. porosus*, from Black Rock, near Bristol, viewed by transmitted light.

There are several kinds of fossil teeth which possess the same structure as those of Psammodus, but differ in their external characters; these are referred to other genera by M. Agassiz. Thus ORODUS, *Lign.* 128, fig. 3, comprises those elongated teeth in which the centre of the crown forms an obtuse transverse cone, traversed by a ridge from which oblique furrows diverge transversely towards the circumference.

CERATODUS (*horn-tooth*) EMARGINATUS. *Lign.* 131, fig. 1.—Very curious dental organs, possessing the same structure as the teeth of Psammodus, are found in the Lias and Oolite; they consist of consolidated plates instead of separate teeth; there was probably but one plate on each side the jaws. The upper margin is generally undulated, apparently from use. These dental plates are composed of two distinct layers; the lowermost portion, or root, is an osseous, reticulated tissue, as in cartilaginous fishes in general; and the upper consists of dentine, with minute parallel vertical tubes, as in Psammodus; these tubes are a continuation of the medullary tissue of the osseous root. In Acrodus, and Ptychodus, the teeth have a distinct coat of enamel; but in Psammodus and Ceratodus, the dentine has no external covering; and, in consequence, its canals open on the surface, and produce the porous, or sandy aspect peculiar to these genera. These fossils occur in the Oolite at Stonesfield, and in the Lias at Aust Cliff, near Westbury, Somerset.

CHIMÆRA. *Wond.* p. 330.—The Chimæra is a remarkable genus of recent Sharks, of which one species, about two or three feet long, inhabits the European seas. This fish, like the extinct *Ceratodus*, has dental organs composed of hard indivisible plates of dentine. These plates, in the living species, are oblong, twice as high as wide, and terminate in front by a transverse, sharp edge; there are four in the upper, and two in the lower jaw. The teeth of several species, some much larger than the recent, have been found in the London tertiary, Chalk, Oolite, and Lias. The first British specimen was discovered in the Chalk-marl at Hamsey; but the nature of the fossil was not suspected by me, until more perfect examples were found in the Chalk, and in the Kimmeridge clay at Shotover, and the sagacity of Dr. Buckland had developed their nature and relations.*

Many species have recently been obtained from the Stonesfield slate, Green sand, &c. All the British specimens are described, arranged, and named, by the eminent palæontologist Sir Philip Egerton, Bart., in an able Monograph of the fossil Chimæroid fishes.† There are such essential differences in the fossil teeth, that Sir P. Egerton has arranged them in several genera. The fossil figured *Wond.* p. 330, was found, with the corresponding tooth, in the same block of chalk. It is distinguished from all other species by its elongated, obtuse point, which must have extended beyond the lower jaw, like the beak of a parroquet; hence M. Agassiz proposes the name *Psittacodon;* it is marked on its inferior face by lines of increase.‡ In some species the vertical external wall of the plate is formed of hard dentine, resembling enamel; in others the dentine is disposed in isolated ramifications, producing a dendritical appearance; the modifications of this structure occasion the differences observable in the dental plates of various species; in some, compact dentine, with parallel canals, prevails in the mass of the tooth;

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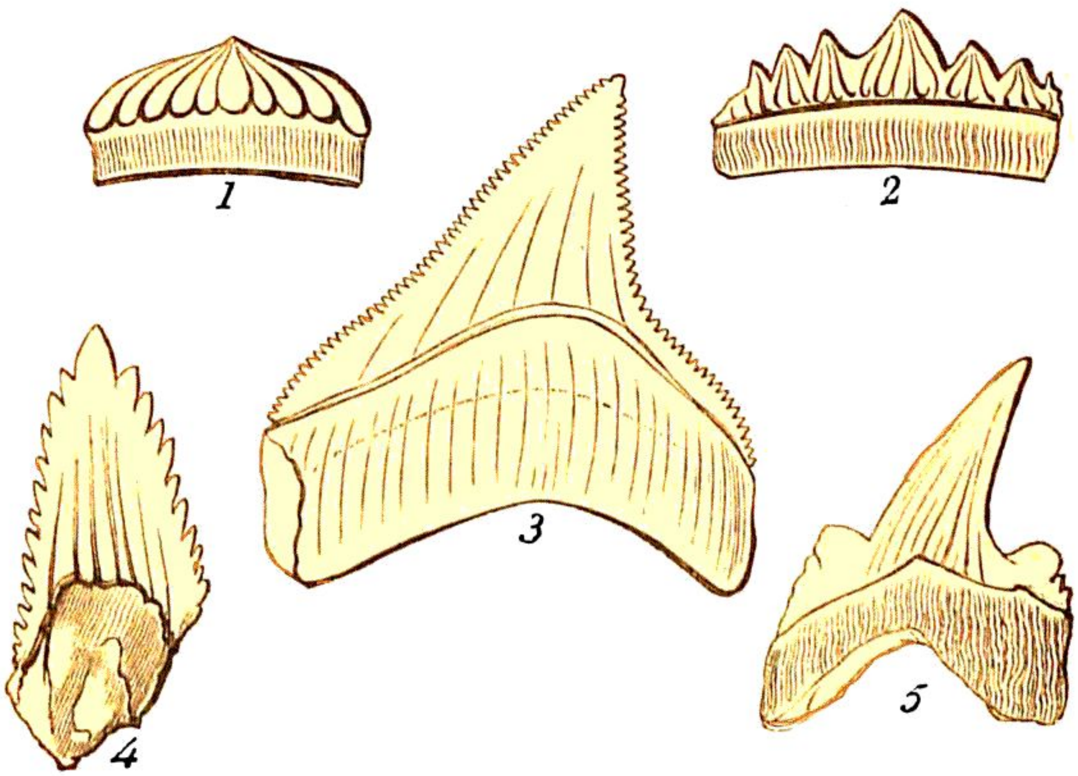
* Proc. Geol. Soc., Vol. II. p. 205.

† Ibid. Vol. IV.

‡ For the microscopical structure of the teeth of Chimæroids, consult Odontography, p. 64.

in others the squamous dentine, with ramifying tubes. In the Kentish Chalk, Mrs. Smith of Tonbridge Wells, has discovered in one block, a pair of mandibles, and a dorsal ray of a Chimæra; this ray is laterally compressed, with a groove at the posterior margin, the edges of which are armed with fine teeth.




LIGN. 129. FOSSIL TEETH OF SHARKS.

Fig. 1.—HYBODUS MEDIUS. *Lias. Lyme Regis.*
2.—HYBODUS RARICOSTATUS. *Lias. Bristol.*
3.—CARCHARIAS PRODUCTUS. *Tert. Malta.*
4.—HEMIPRISTIS SERRA. (*M. Agassiz.*) *Chalk. Ratisbon.*
5.—OTODUS OBLIQUUS. *Tert. Sheppey.*

HYBODUS. *Lign.* 129, figs. 1, 2. (*Bd.* pl. 27[d].)—Intermediate between the obtuse crushing teeth of the Sharks previously described, and those sharp, angular, pointed dental organs of the other genera of squaloids, are those of the fishes which M. Agassiz has arranged in a sub-family or group termed *Hybodonts;* the teeth of which are characterised by their transversely elongated form, and the series of sub-acute, compressed, conical cusps or points, which compose the crown. The median cone is the principal, the lateral points being shorter and smaller, as in *Lign.* 129, fig. 2; in some species the difference between the median and lateral cones is greater, in others less, as in fig. 1. These cusps have a coating of dense enamel, which is plicated longitudinally on both faces. The base, which almost equals the crown in size, is composed of a coarse osseous substance. The internal structure of the crown differs from that of the Cestracionts, in having no principal pulp-cavity, and in being chiefly composed of dendritical dentine, with reticulated medullary canals. The form and organization of these teeth show them to have been instruments for cutting and tearing food. The Hybodonts, as we have already stated (p. 609.), possessed two spinous dorsal fins; in their habits and economy, they probably did not differ from the ordinary Sharks. Teeth of this genus have been found in the New Red system, and are common in the Lias, Oolite, Wealden, and Green Sand. There are several species of teeth and fins in the strata of Tilgate Forest (*Foss. Til. For.* pl. 10.). In general the teeth are found detached, but occasionally they occur in their natural position, and adhering to the mineralized cartilaginous jaws; as in the beautiful fossil figured *Bd.* pl. $27^d$ c. There are several related genera, founded on the situation, form, and division of the principal cusps of the teeth.

SHARKS WITH CUTTING TEETH.—The jaws of the common squaloid fishes, as the LAMNA (*porbeagle*) and CARCHARIAS (*great white Shark*), are so common in collections of natural history, as to render a description unnecessary. The numerous vertical rows of angular, laterally compressed, pointed teeth, with sharp or serrated edges—in some species consisting of a simple trenchant cusp, in others with small lateral teeth, or denticles, at the base, are characters with which all are familiar. Fossil teeth of this form are extremely abundant in the Tertiary and Cretaceous deposits; and are commonly in a beautiful state of preservation. The genera of these fossil teeth are founded on the solidity or hollow structure of the cusps, their possessing cutting or serrated edges, and the presence or absence of lateral denticles. But the last character cannot in every instance be relied upon, for some recent Sharks have rows of teeth both with and without denticles.

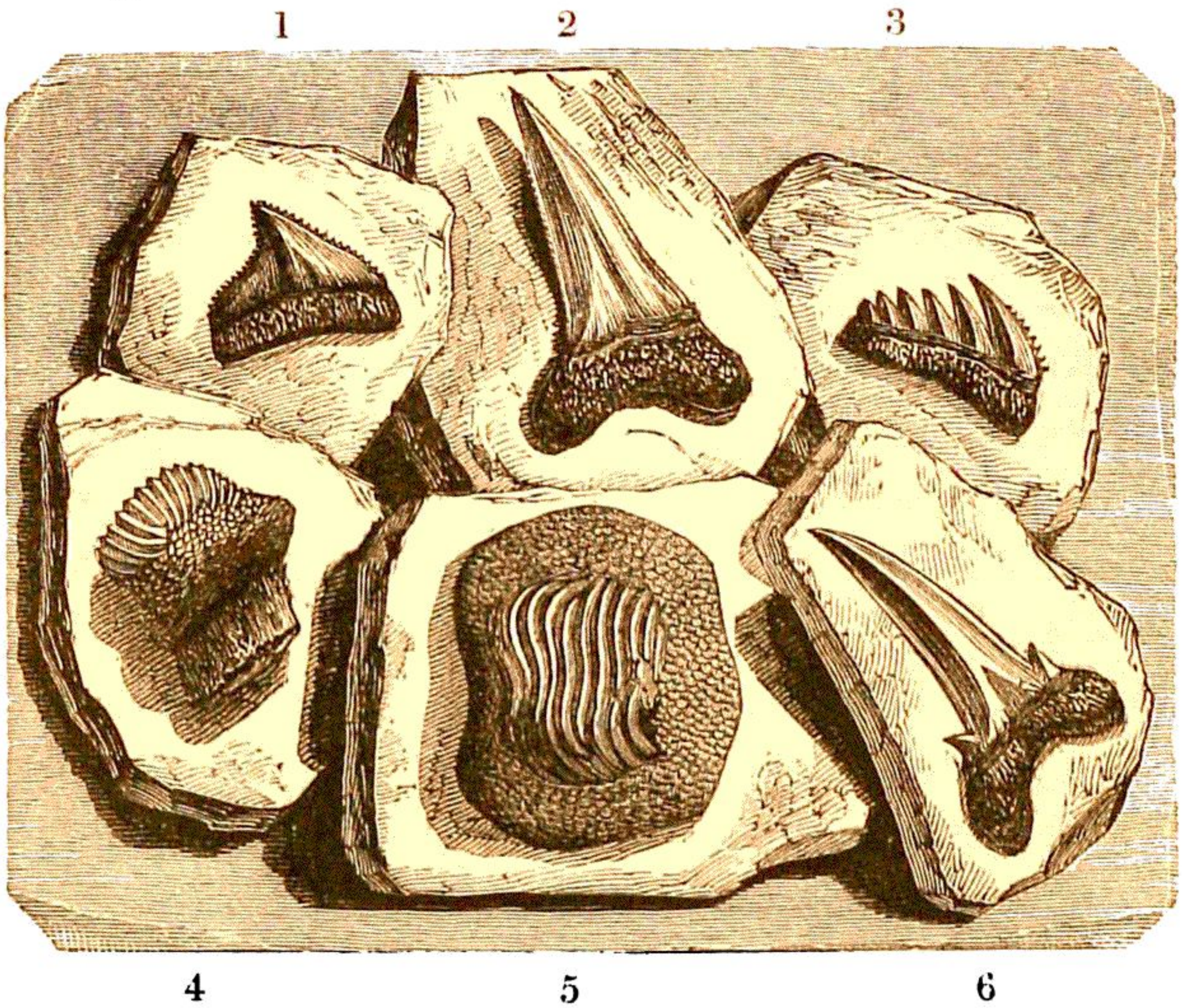
CARCHARIAS PRODUCTUS *Lign.* 129, fig. 3.—The genus *Carcharias* comprises the large Sharks with cutting triangular teeth, crenated (*finely-notched*) on their margins, and having a broad base. In *Carcharodon*, the teeth differ from those of Carcharias in being solid in the centre, while in the latter they are hollow; but in both genera the teeth, when recent, exhibit the same reticulated structure of medullary and calcigerous tubes. The *White Shark*, and other large species, belong to these genera; some of which are upwards of forty feet in length. But even these colossal fishes must have been far surpassed in magnitude by the extinct species of the Tertiary deposits, if the teeth afford a scale of proportions; for some of the fossil teeth from Malta and the United States are six inches long, and five wide at the base;* being twice the size of the teeth in the largest living species. The specimen figured in illustration *Lign.* 129, fig. 3, is of a small size.

HEMIPRISTIS SERRA. *Lign.* 139, fig. 4.—The fossil teeth of this genus are distinguished by serrated edges, that do not extend to the summit, which is a sharp angular point; as in the fossil represented.

LAMNA ELEGANS. *Lign.* 130, fig. 6.—The fishes of the genus *Lamna* (to which the recent shark called the *Porbeagle* belongs) have teeth with smooth trenchant edges, and a small sharp denticle (*little tooth*) on each side the base, as in the fossil, *Lign.* 130, fig. 6. The specimen, fig. 2, although devoid of denticles, probably belongs to the same genus, for reasons already explained. Several species abound in the Chalk; and they are associated with teeth, which are relatively wider and

* Elementary Geology, by Professor Hitchcock. New York, 1841. P. 135.

shorter, and have large compressed denticles; the latter are arranged in a separate genus (named *Otodus*), by M. Agassiz. The specimen figured *Lign.* 129, fig. 5, represents *O. obliquus;* another




LIGN. 130. FOSSIL TEETH OF SHARKS. *Chalk. Lewes.*

Fig. 1.—GALEUS PRISTODONTUS.
2.—LAMNA CRASSIDENS.
3.—NOTIDANUS MICRODON.
4.—PTYCHODUS POLYGURUS; seen laterally.
5.—PTYCHODUS POLYGURUS; viewed from above.
6.—LAMNA ELEGANS.

species, *Otodus appendiculatus*, is abundant in the Sussex Chalk. The large, wide, triangular, smooth teeth, with trenchant edges, and destitute of lateral denticles, so common in the Chalk, are related to *Lamna*, and are comprised in the genus *Oxyrhina* (*Poiss. Foss.* Tom. V. tab. 33.).

NOTIDANUS MICRODON. *Lign.* 130, fig. 3.—These teeth differ remarkably from those of the other genera of Sharks. Each tooth is composed of a single crown, formed of a series of sharp angular enamelled points, the first of which is the largest, and is notched on its anterior edge; the base or root is osseous, flat, with a slight longitudinal depression below the border of enamel. These teeth are comparatively rare in the Chalk. One species has been found in the Oxford Clay; and several in the Tertiary strata. Specimens occur in Hordwell Cliff.

GALEUS PRISTODONTUS. *Lign.* 130, fig. 1.—The teeth of the recent genus *Galeus*, to which the *Tope*, or Grey Shark belongs, are of a triangular form, with a deep concavity or notch on the posterior margin, the base of which is prolonged, and forms three or four angular points: the anterior edge of the tooth is finely serrated. The root of the tooth, as in *Notidanus*, is a broad osseous plate. There is much diversity of form in the Chalk specimens, which are all of a small size, as in *Lign.* 130, fig. 1. In Sussex they are more common in the Chalk-marl than in the Chalk. The fossil differ from the recent teeth in being solid, and on this character M. Agassiz has founded the genus *Corax*, to which the fossil teeth are now referred;

but I have retained the former, and well-known name of *Galeus*.

The only fossil teeth of the Shark family resembling those of the tertiary Carchariodonts, that have been discovered in the strata below the Chalk, are from the carboniferous deposits of Yorkshire and Armagh. These teeth resemble those of *Carcharodon;* they are compressed, triangular, crenated on the edges, with large plaits or folds on the enamelled surface, towards the base of the crown.*

FOSSIL VERTEBRÆ OF SHARKS. — The cartilaginous nature of the skeletons of this family, renders them unfavourable to preservation in the mineral kingdom; and the durable parts already described, and those which are ossified, are the only relics found in a fossil state. The dermal integument is sometimes preserved; and I had a beautiful example of shagreen, composed of irregular minute hexagonal scales, one of which is represented highly magnified, *Lign.* 126, fig. 1. Groups of vertebræ of a large size occasionally occur in the Sussex Chalk; they are circular, biconcave, and very short; one specimen is four inches in diameter, and one inch long; their concavities are consequently shallow. They probably belong to the same fishes as

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* *Poiss. Foss.* M. Agassiz refers these teeth to a new genus, *Carcharopsis prototypus*, from specimens in the splendid collection of Ichthyolites, of the Earl of Enniskillen, at Florence Court, Ireland.

the large smooth teeth (*Oxyrhina*). These vertebræ are composed of two shallow conical disks, which are united, by their summits, at the axis; and are connected and supported by numerous wedge-shape plates, that radiate from the centre to the periphery (see *Foss. South D.* Plate XXXIII. fig. 10.). My collection contained a connected series of forty small vertebræ from the Chalk near Lewes, which probably belonged to the same species of Shark as the dorsal spine; viz. *Spinax major* (*Poiss. Foss.* Tom. III. pl. 40[a.] fig. 6.).

SQUALORAIA. *Poiss. Foss.* Tom. III. pl. 42.—In the Lias of Lyme Regis, that inexhaustible storehouse of fossil treasures, a considerable portion of the skeleton of a very remarkable fish, partaking of the characters of the Sharks and Rays, was discovered by Miss Mary Anning, and is now in the interesting collection of the Bristol Institution.* In this fish the jaws are prolonged into a beak, like the Pristis (*Saw-fish*). It has the head of a Shark, with a long beak; vertebræ of the Rays; with pectoral and ventral fins, almost equally developed; a tail armed with a spine; and spinous bosses, as in the true Rays.

FOSSIL PRISTIS, OR SAW-FISH.—This well-known predatory fish, which is allied to the Rays and Sharks, has projecting from its snout an osseous, flat, horizontal plate, or beak, equal in length to

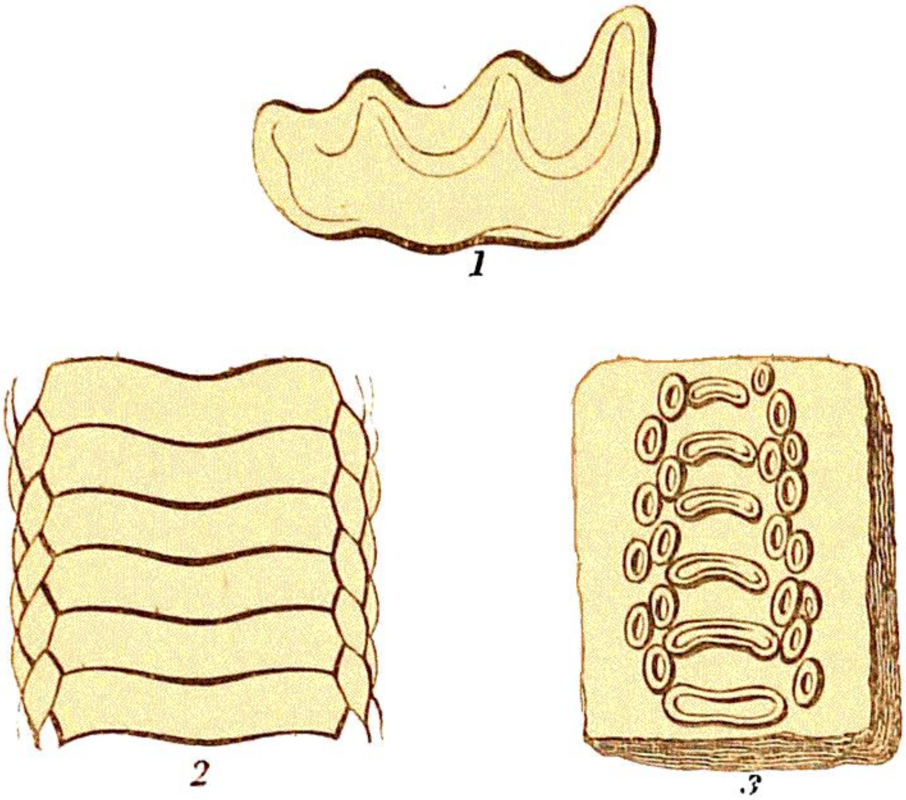
* It is figured and described by Dr. Riley, Geol. Trans. Vol. V. pl. 4.

one-third of the fish, and armed on each side by a row of elongated, compressed, pointed teeth, implanted in sockets; the front margin of these teeth is convex, the posterior concave; this defence is termed the saw. The *Pristis* has also numerous small obtuse teeth on the jaws. The remains of the beak, or saw, of an extinct species of Pristis were discovered by Dr. Buckland in the Bagshot Sand at Goldsworth Hill, Surrey;* and two other species have been found in the clay of the Isle of Sheppey.

FOSSIL RAYS.—The teeth of these fishes are characterised by the extraordinary transversal development of the median teeth in both jaws. Instead of pointed teeth, they have wide, flat, tesselated dentary plates in each jaw, composed of distinct pieces, juxtaposed and connected by their margins, and united by fine sutures. In some species the teeth are equal, in others of various sizes; they present numerous modifications of arrangement, and are always disposed in symmetrical rows. In the genus Myliobatis (*Eagle-ray*) the teeth of the median row are of an extraordinary width, while their length does not exceed that of the lateral plates, or chevrons, which are of an irregular hexagonal form, and disposed in two or three rows on each side. There are five living species of *Myliobatis*, and fifteen fossil; all the latter have been

* Proc. Geol. Soc. Vol. II. p. 687.

found in Tertiary strata. They occur in the Isle of Sheppey, Hordwell Cliff, and Bracklesham Bay. I have figured a specimen of part of the upper jaw



LIGN. 131. FOSSIL TEETH OF FISHES.

Fig. 1.—CERATODUS EMARGINATUS: ½ *nat. Lias. Aust Cliff.* A single dental plate.

2.—MYLIOBATIS MICROPLEURIS: $\frac{1}{3}$ *nat.* (*Agassiz.*) *Isle of Sheppey.* A series of six median teeth, with the corresponding lateral teeth.

3.—PYCNODUS MANTELLI. (*Ag.*) *Tilgate Forest.* This specimen consists of the *vomerine* bone, with a median row of flat, arched teeth, and two rows on each side of elliptical teeth, arranged alternately.

of a species (*M. micropleuris, Lign.* 131, fig. 2.), in which the median teeth are very wide, and have two lateral rows of small, irregularly hexagonal, plates. The surface of the teeth in this species is smooth; but in others it is striated longitudinally (*Bd.* pl. 27[d], fig. 14.). In an allied genus, *Aëtobatis*, the lower jaw projects beyond the upper, and in each there is a row of flat, transverse teeth, *without* lateral plates.

To this notice of the fossil Rays, we may add, that a gigantic *Torpedo* has been discovered in that celebrated locality of Ichthyolites, Monte Bolca; and that Sir Philip Egerton has recently enriched his matchless collection of fossil fishes, by a perfect Ray, belonging to an unknown genus, from Mount Lebanon.

# CHAPTER XVI.

## FOSSIL ICHTHYOLOGY; COMPRISING THE GANOID, CTENOID, AND CYCLOID FISHES.

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THE fishes we have hitherto examined belong to the first order, the *Placoidians;* we now pass to the fossil remains of the second order, the *Ganoidians*, which are distinguished by their brilliant angular scales, formed of osseous, or horny plates, densely covered with enamel. This order contains six or more families, comprising many genera and numerous species; our investigation must be restricted to a selection from the principal genera of the *Ganoids*, properly so called, and of the *Sauroids*, or lizard-like fishes.*

The first family, termed LEPIDOIDES, contains several genera, which are defined as possessing either numerous rows of brush-teeth, or of obtuse conical teeth; flat, rhomboidal scales, arranged

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* The fishes of this order are described in *Poiss. Foss.* Tom. II.

parallel with the body; and an osseous, or partially osseous, skeleton. In one division of this family, the body is either elongated or fusiform, the mouth furnished with brush-teeth only, and the tail heterocercal, or unequally bilobed (see p. 604.). To this group belong several genera, which are restricted to the Secondary formations more ancient than the Oolite; while the other group, with homocercal tails, lived in the Oolitic and Cretaceous seas. Two genera, in particular, abound in the Triassic and Carboniferous strata; namely, *Amblypterus* and *Palæoniscus.*

AMBLYPTERUS. *Wond.* p. 681. *Bd.* pl. 27[b].—The fishes of this genus, as the name indicates, have very large and wide fins, composed of numerous rays. The scales are rhomboidal and finely enamelled; the tail is heterocercal. The figures referred to convey a correct idea of the form and external characters. Beautiful pyritous imprints of Amblypteri occur in the Carboniferous slate of Saarbrück, in Lorraine; and fine specimens in the ironstone nodules of the same locality. On the shore at Newhaven, near Leith, similar fossils occur in nodules washed out of the cliffs of coal-shale (*Bd.* p. 278.).

PALÆONISCUS. *Ly.* II. p. 98.—The fishes of this genus differ from those of Amblypterus in the relative moderate size of the scales, and the numerous little rays on their margins. They have rhomboidal scales, which in some species are very small, and in others large. They have numerous brush-teeth. Several peculiar species, found in the slates and magnesian limestones of the Triassic, or New Red system, are very widely distributed, occurring in Scotland, England, Germany, and the United States.*

In some localities the small species occur in groups; on the surface of a slab of stone, from Armagh, not exceeding two feet square, between two and three hundred perfect fishes are imbedded (*Ly.* II. p. 99.).

A remarkable circumstance relating to the fishes of this genus is the almost constant absence of the bodies of the vertebræ, in otherwise well-preserved specimens, and in which the spinal processes and the ribs are entire. As occasionally examples occur with some of the vertebræ perfect, M. Agassiz imputes the absence of these bones in other instances to some physical agency, which destroyed the bodies of the vertebræ, and left the ribs and processes entire. A more satisfactory explanation of the phenomenon may perhaps be found in the probable original cartilaginous nature of the bodies of the vertebræ, and the osseous structure of the enduring apophyses and ribs;† while those rare specimens

* I have received beautiful examples from my friend, Benjamin Silliman, jun. Esq. of Yale College, the highly intelligent junior editor of the American Journal of Science.

† Professor Owen states that a similar condition of the spinal column obtains in the fossil Microdonts.—*Report Brit. Assoc.*

which possess a few bony vertebræ may be regarded as exceptions, in which ossification took place in a structure essentially cartilaginous.*

The fishes of the genus Palæoniscus are often found in the shales and marls of the Triassic and Carboniferous systems of England and Scotland. At East Thickley, in the county of Durham, and Caithness, in Scotland, numerous specimens have been found.† The lower Carboniferous strata at Burdie-house, a locality we have before mentioned, have yielded several new species of Palæoniscus, associated with teeth and other remains of large sauroid fishes.‡ On the continent they alike prevail in deposits of the same epoch; Eisleben and Mansfeld, in Saxony, are well-known localities. In North America they have been discovered in Triassic strata.§ In fine, the genera Amblypterus

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* In some recent fishes the spinal column is not composed of bony vertebræ, but consists of a continuous, cylindrical, gelatinous chord, with an external ligamentous sheath; while the processes which protect the spinal marrow are ossified. This is strikingly exemplified in the *Lepidosiren*, a cycloid fish from the river Gambia; the skeleton is partly cartilaginous, and partly osseous; and the bones are of a green colour, as in the Gar-pike. See Professor Owen's Memoir on the *Lepidosiren annectens*; Linnean Trans. Vol. XVIII. Part 3.

† See Professor Sedgwick on Magnesian Limestone; and on the Deposits in the North of Scotland; Geol. Trans. Vol. III. new series, plates 8—12, pp. 77, and 159.

‡ Dr. Hibbert's Memoir on the Fossils of Burdie-house.

§ Geology of Massachusetts, by Professor E. Hitchcock.

and Palæoniscus may be regarded as characteristic "medals" of the geological epoch which intervened between the Devonian and Oolitic formations.

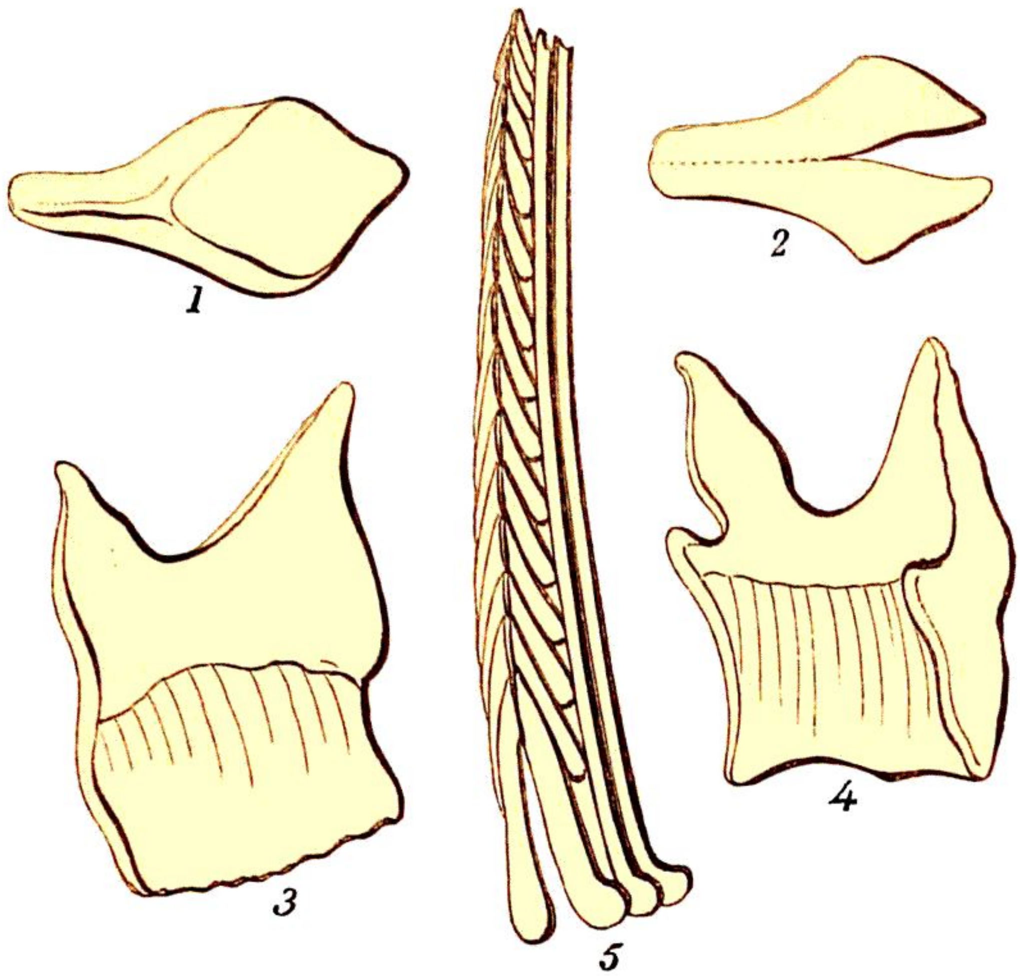
We will next examine a few genera of the homocercal Lepidoids, whose relics are chiefly distributed in the Lias, Oolite, and Wealden.

DAPEDIUS. *Wond.* p. 459.—At Lyme Regis, and other productive localities of the fossils of the Lias, large masses of angular enamelled scales, and occasionally entire specimens of the fishes to which they belonged, have for many years been collected. Sir H. De la Beche first scientifically investigated the structure of these Ichthyolites, and pointed out their characters and relations. The numerous examples subsequently brought to light establish, according to M. Agassiz, two genera; but the difference observable in the external form of the teeth, and which is the only constant obvious distinction, scarcely warrants a generic separation. The Dapedius (of which a restored figure is given *Wond.* p. 459) is a wide, laterally compressed fish, with a rounded head, and fins of moderate size. The body rapidly contracts towards the pedicle of the tail, the fin of which is large, and symmetrically lobed. The mouth is furnished with several rows of small, conical teeth, which are crenated at their summits, and has brush-teeth on the palatine bones; the jaws are short. The scales are rhomboidal, highly polished, and united laterally by short processes; as in many other ganoid fishes. In the other genus (*Tetragonolepis*) the teeth are pointed, and not crenated at the apex, as in Dapedius (*Poiss. Foss.* Tom. II. p. 181.).

LEPIDOTUS.* *Lign.* 132, 133.—Scales of a dark-brown, almost black colour, with a glossy enamelled surface, of a rhomboidal, or lozenge form; and teeth equally dark and glossy, of an obtuse hemispherical figure, are very common in the Wealden strata of the south-east of England, and in the Isle of Purbeck. They are called by the quarrymen *fishes' scales* and *eyes*. The collectors of the last century used to term the obtuse, circular teeth of this and the related genera *Bufonites*, from a supposition that they were formed in the heads of toads. These relics belong to an extinct genus named *Lepidotus*, which contains numerous species, that are distributed in the Oolite and Wealden formations. These fishes resembled the Carps in their general form, but they have no anatomical relations to that family. The body is covered with large rhomboidal scales, which are protected on the external surface by a thick plate of enamel (*Lign.* 132, fig. 3.). The lateral line, which is slightly arched, passes direct from the operculum to the middle of the insertion of the caudal fin. The head, and even the face, are cased with osseous and enamelled plates. The bones of the surface of the skull are very large, and con-

* Poiss. Foss. Tom. II. p. 233.

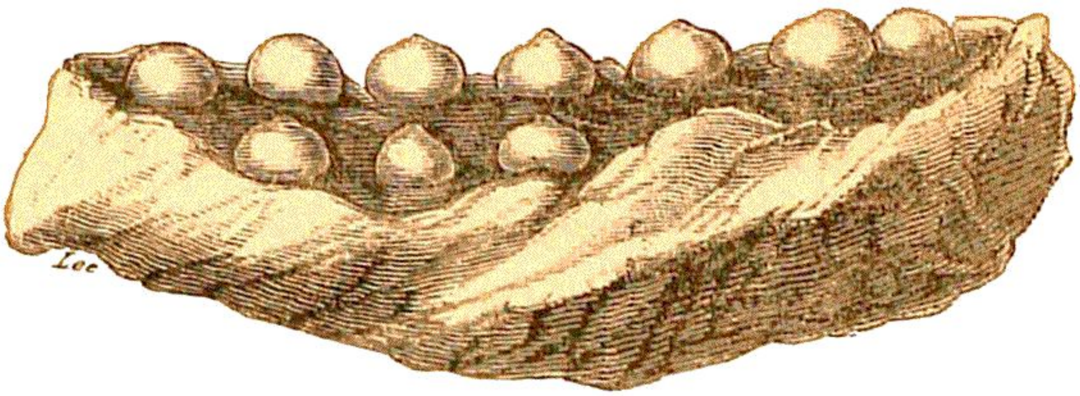
nected by sinuous sutures. The jaws are short and rounded, and furnished with a row of obtuse, conical,




LIGN. 132. SCALES AND FIN OF LEPIDOTUS MANTELLI. *Tilgate Forest.*

Fig. 1.—Scale, with a single process of attachment.
2.—One of the scales of the lateral line.
3.—Scale (external surface), with a bifurcating process of attachment; the enamelled visible portion has longitudinal grooves, or folds.
4.—Scale (viewed on the inner surface), having a bifurcating process of attachment, and a tooth, or projection, on each side, to connect the scale laterally with the adjoining scales.
5.—The front RAY of the dorsal fin, covered with two rows of enamelled scales, and two other rays behind it.

circular teeth (see *Lign.* 133.), and several rows of sessile teeth, more or less contracted at the base, which forms a very short pedicle that is anchylosed to the bone. The fossil Lepidoti are found, for the most part, in fluviatile deposits, as in the Purbeck and Wealden strata; and it is probable they inhabited the rivers or sea-coasts, and not deep waters.



LIGN. 133. PORTION OF THE JAW OF LEPIDOTUS. *Tilgate Forest.*

This specimen shows three successional teeth, beneath a row of teeth in use.

The scales and teeth figured *Lign.* 132, 133, belong to the larger species of the Wealden. The remains of this fish were first collected in Tilgate Forest, and several teeth and scales are figured *Foss. Til. For.* pl. 5. and 10.; considerable portions of connected scales have since been found; also the head entire, and the fins more or less perfect. A specimen in my collection retained a mass of the scales near the insertion of the tail, a foot wide; indicating the original to have been twelve feet long, and its body three feet broad. The scales are distinguished from other species by the folds or grooves on their enamelled surface; and the teeth by the contracted base, or pedicle, which is a little narrower than the crown (*Lign.* 133, and Pl. VI. fig. 10.). A species (*L. Fittoni*, G. A. M.) closely related to the above is equally abundant in the Weald of Sussex; the scales are not striated, and the teeth have no pedicle.

The intimate structure of the teeth of the Lepidotus is beautifully preserved, and may be easily examined in thin transverse and vertical sections, viewed by transmitted light: see Pl. VI. fig. 10. The dentine is composed of bundles of tubes, continued from the cells of the osseous base, radiating in a vertical direction to the surface of the tooth, as seen in Pl. VI. fig. 10, and giving off branches at an acute angle; but when more highly magnified, the finer branches are spread out, and arched at their extremities, "presenting the appearance of the stems of corn, beaten down by heavy rain."*

The dorsal and pectoral fins of these fishes are very strong, and consist of several bony rays. There is a double row of acuminated, enamelled scales, arranged more or less obliquely, on the anterior margin of the dorsal and anal fins, and on both margins of the caudal: part of the first ray of a dorsal fin, with scales, is represented *Lign.* 132, fig. 5.

A small species of Lepidotus (*L. minor*) is common in the Purbeck limestone, and specimens may

* Odontography, p. 70. See the beautiful representation of this structure, pl. 31.

often be procured from the quarries near Swanage; it has also been found at Hildesheim, in Saxony, by M. Roemer. The detached scales abound in the limestones; and the splendid fossil reptile from Swanage, figured *Wond.* Pl. I., is sprinkled with the scales and minute teeth of this fish. The habits of the Lepidoti, as indicated by the form and structure of the teeth, were those of fishes whose food consisted of crustaceans, shelly mollusca, &c.; for the dental organs are peculiarly adapted for the crushing and grinding of such substances; and the teeth of the adult fishes are generally worn down by use.

Pycnodus. Pl. I. fig. 3; *Lign.* 131, fig. 3.—The fishes of the family of Pycnodonts, so named from the thickness of their teeth, have an osseous skeleton, a flat and wide body, covered with rhomboidal scales, and flat or rounded teeth, disposed in several rows, on the palatine, vomerine, intermaxillary, and premandibular bones.* As in the Lepidotus, these teeth are constructed for crushing, and have generally a smooth, dense, convex, or flattened crown, with a highly polished surface. A perfect fish of the genus Pycnodus (*P. rhombus*), from the Jura limestone, at Torre d'Orlando, near Castellamare, is figured in the frontispiece of the first volume of this

* The *intermaxillary*, *palatine*, and *vomerine* bones compose the vault, or roof of the mouth; the vomer occupying the middle; the intermaxillary the front; and the palatine bones the sides: the *premandibular* bones belong to the lower border of the mouth.

work; and a *vomerine* bone, with teeth, from Tilgate Forest, in *Lign.* 131, fig. 3. In the last fossil there is a median row of flat, elongated, transversely arched, smooth, glossy teeth, with a double alternate row of small sub-circular teeth on each side, attached to the bone, which is imbedded in Tilgate grit. Specimens of this kind, of several species of Pycnodus, are not uncommon in the Wealden of Sussex: they were among my earliest discoveries in Tilgate Forest (*Foss. Til. For.* pl. 17, figs. 26, 27.). Examples occur in which all the teeth are shed, and the bony plate of the vomer alone remains.

GYRODUS. *Lign.* 134.—In another genus of the PYCNODONTS, termed GYRODUS, the crowns of the teeth are deeply furrowed, the structure of the dentine is very dense, and the pulp-cavity large and simple. One species occurs in the Speeton clay of Yorkshire, and another in the Sussex chalk. As in Pycnodus, the teeth are distributed in rows on the bones composing the roof, floor, and sides of the mouth.

These characters are beautifully displayed in the Russian specimen, *Lign.* 134. This interesting fossil was presented to me by Stephen Cattley, Esq. who collected it in 1839, in a valley near RJEFF, a village on the banks of the Volga. Mr. Cattley informed me "that many fossils are found in that and the neighbouring valleys, and the locality is frequented by Russian geologists, when the season permits; which is but seldom, owing to the long duration of the snow, and the heavy rains which accompany the thaw." This specimen consists of

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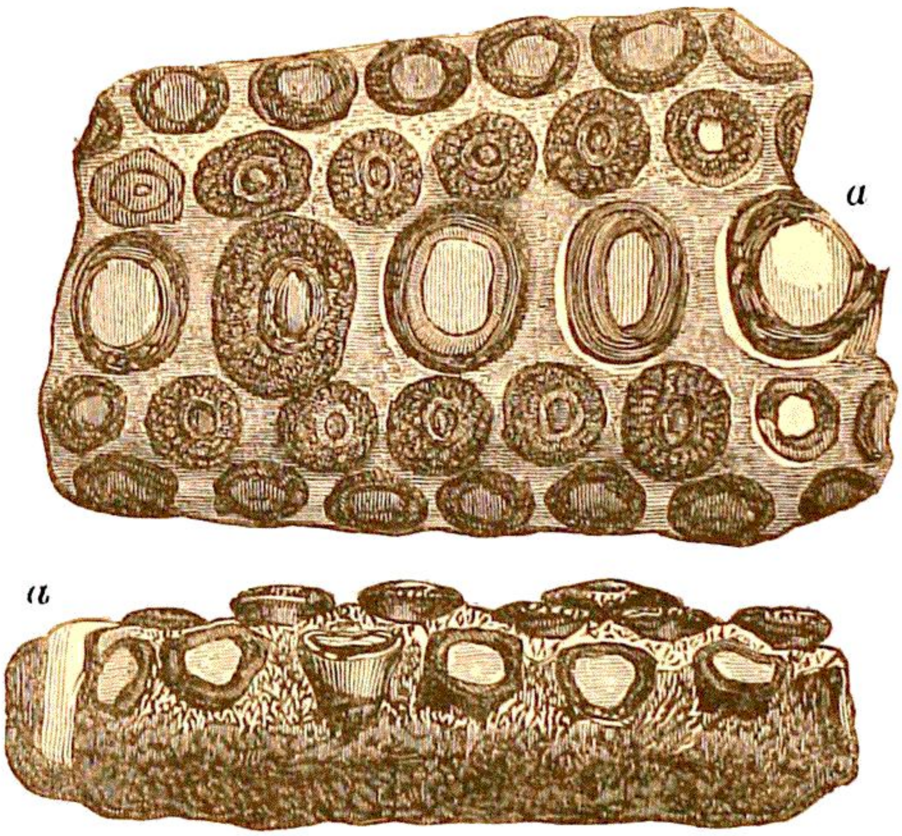


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LIGN. 134. GYRODUS MURCHISONI* (G. A. M.). *Russia.*
(*Collected by Stephen Cattley, Esq.*)

Fig. 1.—The vomerine bone of a fish, with five rows of teeth; seen from above; many of the crowns of the teeth are worn away by use, and the large pulp-cavities, filled with white spar, are exposed; as at *a*.

2.—Lateral view of the same.

*a*. One of the pulp-cavities filled with spar.

the vomerine bone, which is of a coarse texture, and

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* It is with peculiar pleasure that I inscribe this new species of *Gyrodus* to R. I. MURCHISON, ESQ., *Pres. Geograph. Soc.*, in commemoration of those extended and successful geological researches in the Russian empire, which have conferred additional honour on his distinguished name.

five rows of teeth; the median row consists of very large elliptical teeth; those of the lateral rows are much smaller and arranged alternately. The peculiar structure of the teeth of this genus, so admirably elucidated by Professor Owen,* is finely displayed in this fossil. The ample, deep, and simple pulp-cavity is seen in several teeth where the crown of dentine has been worn off, filled with a pure white calcareous spar; one of these cavities is marked *a*. The dentine is extremely dense, consisting of very minute calcigerous tubes, and passes into an external layer of enamel.

The fishes of the genus *Gyrodus*, have the body large, flat, and elevated; the dorsal and anal fins very long; and the tail forked, with equal elongated lobes. The scales are laterally connected by strong processes, as in Lepidotus. Other genera of the lepidoid family occur in the Oolite; as for example, *Microdon*, thus named from the smallness of its very numerous flat angular teeth, arranged in many rows; and *Placodus*, in which the teeth are few and of great size.†

In all these fishes, the obvious construction of the dental organs, is that of an apparatus for the comminution of hard bodies, as crustaceans, testaceous mollusks, and food of a similar kind.

* Odontography, p. 72.

† Ibid. pl. 43, fig. 1, and pl. 30, fig. 2.

Ganoid Fishes of the Devonian System.—The remains of three genera of ganoid fishes of a very remarkable character, are principally, if not exclusively, found in the Devonian or Old Red system; most frequently in Scotland, but also in Shropshire, Herefordshire, and other districts of England and Wales. These fishes agree in one general character, that of having enormous osseous, or horny plates or scutcheons; their general aspect will be understood by reference to *Lign.* 135; and *Wond.* p. 682. These fishes are not at present arranged by M. Agassiz; but Sir Philip Egerton informs me, that they will probably constitute a distinct family with the name *Cephalaspides*, from the character of the first genus we propose to describe.

Cephalaspis Lyellii. *Wond.* p. 682.—The most striking feature in the Ichthyolites of this genus, is the enormous scutcheon, or buckler, which forms the head, and is prolonged posteriorly into two lateral horns or points; this part so closely resembles the cephalic shield of certain trilobites (see *Lign.* 121.), that the first specimens were supposed to be the remains of unknown crustaceans. The name *Cephalaspis* (*buckler-head*) is derived from this character. This remarkable appearance is occasioned by the intimate anchylosis of all the bones of the cranium. The body of these fishes is relatively smaller than the head, has two dorsal fins, and terminates in a tail with a long pedicle, supporting a fin. There are two very small eyes, placed towards the middle of the head. The whole body is covered with rhomboidal scales; and the head with discoidal scales, which are highly ornamented with radiated markings* (*Ly.* II. p. 149.).

The other genera are equally unlike any recent types of the class of fishes. No perfect examples have been found, and some parts of their structure are still unknown; the annexed figures, *Lign.* 135, have been drawn by Mr. Dinkel (the eminent artist employed by M. Agassiz), with scrupulous accuracy, no part being introduced which is not clearly demonstrated in some one specimen; and the form of the scutcheons are made out very distinctly, to aid the collector in discriminating the detached plates, which are the most common relics of these singular beings.

PTERICHTHYS CORNUTUS. *Lign.* 135, fig. 1.†—This fish is distinguished by its two wing-like lateral appendages; whence the name of the genus (*winged-fish*). These processes, like the spines of the common Bull-head (*cottus gobio*), are weapons of defence. In some specimens they are extended at right angles to the body (*Ly.* II. p. 150.).

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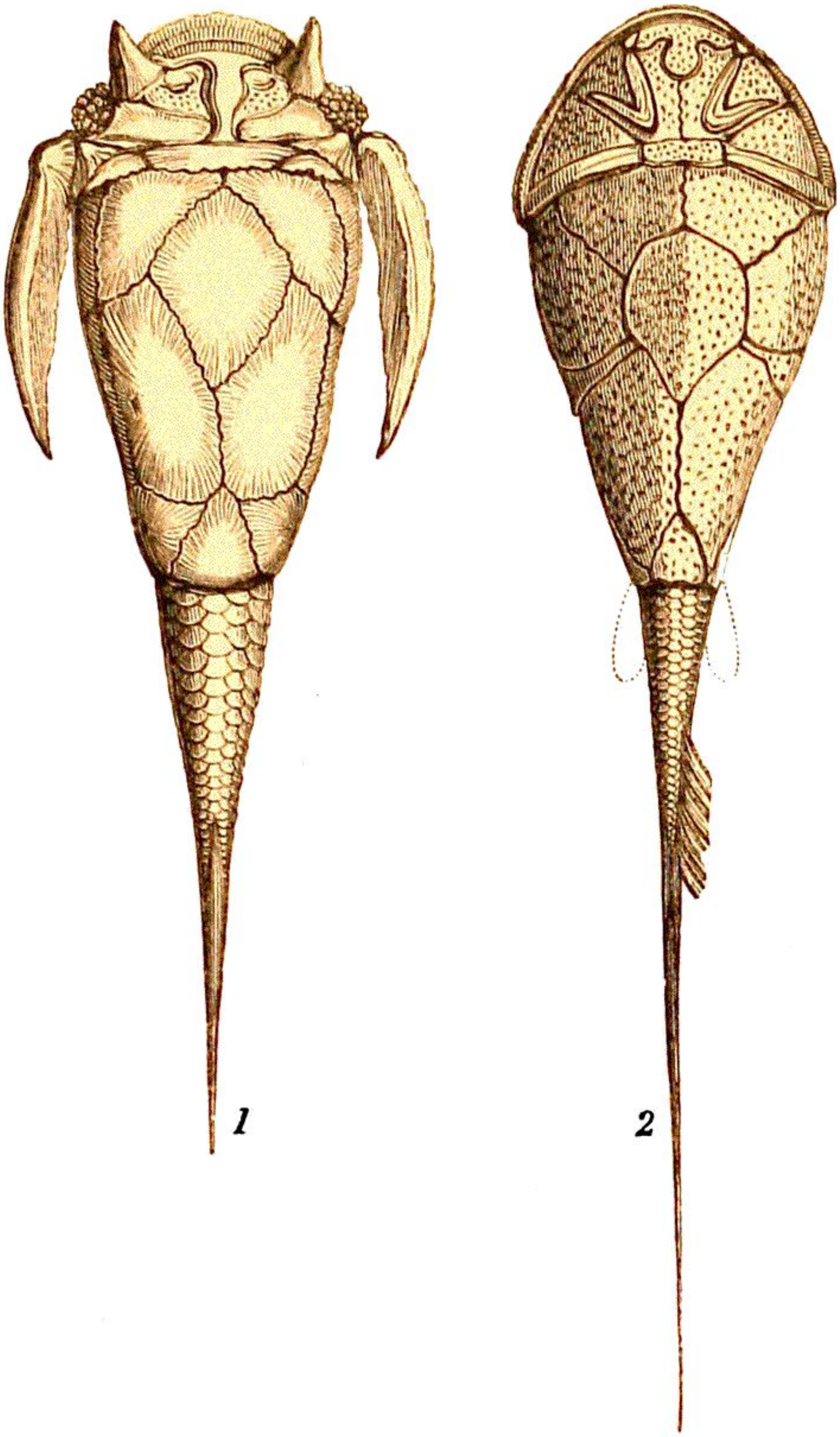
* *Poiss. Foss.* Tom. II. p. 135.

† The first fish of this genus was discovered by Mr. Hugh Miller, in whose charming little work, "New Walks in an Old Field," will be found a very graphic description of the Old Red fishes; I know not a more fascinating volume on any branch of British geology.

The head and anterior part of the body are covered with large angular tuberculated scutcheons. The under surface of the body is flat and protected by five plates; one, of a quadrangular form, occupying the centre. The upper part of the body is convex; the form and disposition of the dorsal scutcheons are shown in *Lign.* 135, fig. 1. There are two eyes, which are placed in front of the lateral spines; see fig. 1. The tail is of an angular form, and as long as the body; it is covered with scales, and considered by M. Agassiz to have been the only instrument of locomotion. The British species of this genus, of which five or six are known, are all very small, varying in length from one to eight or ten inches. But in the Devonian strata of Russia enormous species occur; I have seen in Mr. Murchison's collection specimens and models, in which the lateral spines exceed one foot in length.

COCCOSTEUS OBLONGUS. *Lign.* 135, fig. 2.—The fishes of this genus, as may be seen by the lignograph, very much resemble those of Pterichthys; in both the osseous scutcheons of the body are very similarly disposed. In *Coccosteus*, the head is rounded; the eyes have not been discovered. There are no lateral spines represented in the figure; for in none of the specimens examined by Mr. Dinkel were any traces perceptible; but the late Lady Gordon Cumming informed me, that her cabinet contained one example, in which spines, resembling




LIGN. 135. FOSSIL FISHES, OF THE DEVONIAN SYSTEM.

(*Drawn by Mr. Joseph Dinkel.*)

Fig. 1.—PTERICHTHYS CORNUTUS, seen from above.

2.—COCCOSTEUS OBLONGUS; upper surface.

These figures are restored with great accuracy, from the best preserved specimens hitherto discovered.

those of Pterichthys, were distinctly seen. The tail is very long, covered with scales, and supports a fin; see fig. 2.*

The plates of the body are tuberculated, as in Pterichthys. The mouth is supposed by Mr. Miller to have been placed vertically; but the evidence as to this anomalous character is not conclusive. The dental organs are stated, by the same sagacious observer, to have been vertical plates with serrated margins; appearing like the teeth of a saw.†

These fishes are from a few inches to two feet in length; four or five species have been discovered; and their remains are the most abundant of the Ichthyolites of the Old Red. Patches of detached scales, and insulated osseous plates, are very frequent in the sandy cornstones, and the subcrystalline masses of limestone. These fragments are usually of a brilliant blue or purple colour; and strongly contrasting with the dull red tint of the surrounding rock, are easily recognised. The colour is supposed

* The above restorations are upon the authority of Mr. Dinkel; and were made after he had inspected all the best collections of these Ichthyolites. I have only imperfect specimens in my own cabinet; but the late Lady Gordon Cumming gave me the opportunity of examining some choice examples in London. The great length of the tail in *Coccosteus*, is based on a specimen seen by Mr. Dinkel since his return to Neufchatel. For the accuracy of all the other original figures in this work, the author is accountable.

† Miller's New Walks in an Old Field; plate 3, fig. 4, p. 52.

to be due to the presence of phosphate of iron, which has communicated a similar tint to the Ichthyolites of the Caithness Schist.*

FOSSIL SAUROID FISHES. (*Poiss. Foss.* Tom. II.) —The family of Ganoid fishes termed *Sauroid*, or lizard-like, by M. Agassiz, are so named in consequence of certain peculiarities in their organization which are found in no other animals of this class, but exist in reptiles. There are but two living genera; namely the *Lepidosteus*, of which there are many species that inhabit the rivers of America; and the *Polypterus*, that contains two species, one inhabiting the Nile, and the other the rivers of Senegal. In these fishes the bones of the skull are closely connected by sutures; the teeth are large, conical, and longitudinally striated, as in the crocodile, plesiosaurus, &c. the spinous processes are united to the bodies of the vertebræ by suture, as in most reptiles; and the ribs are articulated to the extremities of the transverse processes; the skeleton is osseous. Even in the soft parts many analogies are presented; thus the Lepidosteus has a glottis, as in the *Siren;* and a cellular air-bladder, with a tracheal vessel, resembling the lungs of an Ophidian (*serpent*). These fishes are the only living representatives of those voracious tribes of the most

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* Murch. Sil. Syst. p. 588; see also a detailed description of the Cephalaspis, Holoptychus, and other Devonian Ichthyolites, by M. Agassiz, p. 589—601.

ancient marine fauna, whose remains abound in the secondary formations. Their relics have often been mistaken for those of reptiles; particularly the teeth, which from their large size, conical figure, enamelled and striated surface, and internal cavity, were generally supposed to belong to crocodiles. The scales are flat, rhomboidal, and parallel to the body. The recent *Lepidosteus osseus*, of North America, affords a good illustration of the fossil genera; a reduced figure of this fish, from *Poiss. Foss.*, will be found in *Bd.* pl. 27[a.]; and several teeth of fossil Sauroids are represented *Bd.* pl. 27.

The teeth of the Sauroids consist of two kinds; the pointed, striated cones, and numerous small brush-teeth. The intricate structure of the conical teeth of the *Stony-gar*, or Lepidosteus, is very remarkable, and presents a striking analogy to that discovered by Professor Owen in an extinct genus of reptiles, of which we shall treat in a subsequent chapter. The tooth consists of a large conical pulp-cavity, surrounded by a mass of dentine, which is plicated longitudinally, its folds giving to the pulp-cavity an appearance of being divided into parallel longitudinal branches; resembling, in this respect, the base of the tooth of Ichthyosaurus, as shown in a transverse section, Plate VI. fig. 9. If we imagine these folds to be multiplied, and to have more inflections, and the pulp-cavity to be reduced in its proportions, we shall have the elegant organization of the teeth of the *Labyrinthodonts* (see Plate VI.

fig. $3_{b.}$). The dentine is composed of very minute calcigerous tubes, which pass off at right angles from the pulp-cavity to the periphery; and it is covered by a layer of cement, or coarser dentine, which is encased in a coat of enamel, forming the external investment of the tooth.* The long conical teeth are implanted in *alveoli* or sockets, to the walls of which they are anchylosed at their base.

The teeth of several extinct genera of sauroid fishes occur in the Chalk, Oolite, Lias, and Carboniferous formations; but none have been observed in the Tertiary deposits. I have not observed any trace of this family in the Wealden. The great strength and size of some of these teeth, prove that the seas of those remote periods were inhabited by voracious fishes of enormous magnitude.

The teeth and jaw of a gigantic sauroid (*Megalichthys*), from the Carboniferous strata at Burdiehouse, are figured *Bd.* pl. 27; the sections of the teeth shown in figs. 13, 14, of that plate, illustrate the size of the pulp-cavity and the thickness of the layer of dentine. These remains were associated

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* These remarks are based on M. Agassiz's description and my own observations. An interesting paper, "On the Microscropic Structure of the Teeth of the *Lepidostei*, and their analogy with those of the *Labyrinthodonts*, with a plate," by *Dr. Jeffries Wyman*, will be found in Amer. Journ. of Science, October, 1843, p. 359.

with the plants and crustaceans previously described; an assemblage of fossils indicating a lacustrine or estuary formation. Similar teeth have been found in the cannel-coal of Fifeshire (*Ly*. II. p. 110.).

In the Devonian strata the remains of several large sauroid fishes occur. Of these, one of the most remarkable is the genus *Holoptychus*, distinguished by the peculiar structure of the scales; the enamelled surface of which is covered by undulated furrows. The whole body is covered by thick enamelled scales of this kind. A splendid specimen, twenty-eight inches long, and twelve wide, is figured *Murch. Sil. Syst.* pl. 2 *bis.* Scales have been found exceeding three inches in length, by two and a half in width; which must have belonged to a fish of great magnitude (*Ly*. II. p. 149, fig. 331.).

Dendrodus. Pl. VI. fig. 8.—In the Old Red sandstone of Elgin, at a quarry at Scat-cray, some teeth have been found with a very remarkable structure; they are referred by Professor Owen to a genus of sauroid fishes, which, from the dendritical or arborescent disposition of the calcigerous tubes, he has named *Dendrodus*. The teeth are of a conical form, slightly curved, and solid throughout. They are finely striated longitudinally, on the external surface, and have two opposite vertical ridges; the base is rough, and its margin rounded, as if for attachment to a shallow socket. The largest specimen is one and a half inch in length. In thin sections, viewed microscopically by transmitted light, there is a central pulp-cavity, of small size; the medullary canals pass into a few short ramifications, like the branches of a shrub, and these are distributed into irregular dilatations, simulating leaves, which resolve themselves into radiating bundles of calcigerous tubes; a portion of Professor Owen's figure of a transverse section, is shown Pl. VI. fig. 8.*

ASPIDORHYNCHUS. *Bd.* Pl. 27[a], fig. 5.—In the lithographic stone of Solenhofen, specimens of sauroid fishes, closely related to the *Lepidosteus*, are discovered; they differ from the recent species, in the extreme shortness of the lower jaw, and the prolongation of the upper into a beak; in the very high scales on the flanks; and the homocercal tail. The figure of the fossil fish referred to, is contrasted on the same pl. 27, *Bd.* with that of its recent analogue; and the characters of these sauroid fishes are thus admirably elucidated.

SAUROID FISHES OF THE CHALK.—In the Shanklin sand, and also in the Galt of Kent and Sussex, very large, conical, striated teeth, belonging to sauroid fishes, are occasionally found. They invariably occur detached, and no portion of the jaws has been observed. In the upper Chalk, near Lewes, conical teeth, marked with fine longitudinal striæ, having a simple pulp-cavity, and a smooth, excavated base, are found with the remains of sharks, rays, &c. (See *Foss. South D.* Tab. XXXIII. figs.

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* See Odontography, pl. 62 B. fig. 2.

1, 8.) But the most remarkable fish of the Sauroid family, that inhabited the sea which deposited the chalk, is the *Macropoma*, belonging to the group of sauroids, having an elongated fusiform body, with a regular tail.

MACROPOMA MANTELLI. *Wond.* p. 334. (*Foss. South D.* Tab. XXXVII. XXXVIII.)—This fish is generally from one to two feet in length, of an elongated, fusiform shape, with a large head, and two dorsal fins; the anterior fin is imbedded, and has seven or eight strong spinous rays, the two first of which have numerous spines. The opercula are very long and large; the scales are garnished with adpressed spines, disposed in semicircular rows (see *Lign.* 126, fig. 2.). The teeth are small, conical, and numerous.

Several specimens of this fish are almost perfect; from the snout to the extremity of the tail. The bones of the cranium, the jaws, teeth, opercula, branchial rays, palatine arches, the surface of the body covered with scales, all the fins, the pelvic bones, the vertebræ and their apophyses, all remain.

In one example, the *vomer*, covered with minute teeth, is exposed. But the most extraordinary fact relating to these Ichthyolites, is the preservation, in every specimen, of the *stomach;* even its membranes remain, and separate in flakes; and the ramification of the minute vessels is visible, with a high magnifying power. In some instances the stomach is displaced and much distended; but in general it occupies its natural position, and retains its elongated, sub-cylindrical form, with a few annular membraneous constrictions or folds. It has so much the appearance of the *air-bladder*, that I described it as such, *Foss. South D.* M. Agassiz first discovered its true character.

COPROLITES. *Lign.* 99, figs. 1, 2.—In more than one example the solid, earthy residue of digestion, in small lumps, of a conical form, and spirally convoluted, lies in the abdomen. Fossil excrementitious remains of this kind are termed *Coprolites* (*Bd.* p. 198, pl. 15.), and are found in many deposits; belonging not only to fishes, but to large reptiles, and other animals. *Lign.* 99, p. 432, fig. 1, represents the coprolite of a *Macropoma;* and fig. 2, of a species of *Shark*, from Hamsey. The convoluted appearance of these bodies arises from the peculiar organization of the intestinal canal of the original fishes; in which, as in the recent Dog-fish, a portion of the intestine was spirally twisted, the tube forming several gyrations; and the passage of the calcareous substance through this constricted canal, gave rise to the structure observable in the coprolites. In the Macropoma the gyrations appear to have been few; seldom more than five or six turns being apparent. In the fossil Sharks the convolutions are more numerous, ten or twelve occurring in the length of an inch. In many of the coprolites, the microscope detects the impression of the mucous or lining membrane of the intestinal canal. Some of the coprolites of the Macropoma are not convoluted; probably from having occupied the upper part of the digestive tube, and therefore not having been moulded in the spiral part. (See *Geol. S. E.* p. 145. *Foss. South D.* Tab. IX.) Minute scales and bones of fishes are occasionally imbedded in the substance of the coprolites; affording evidence of the carnivorous habits of the Macropoma.*

COLOLITES. *Bd.* pl. 15[a].—It will be convenient to notice in this place those curious fossils which occur in detached masses in the limestone of Solenhofen, and were known to collectors by the term *lumbricaria*, from the supposition that they were petrified earth-worms. An excellent representation of a fine specimen is given by Dr. Buckland in the plate referred to above. These convoluted bodies M. Agassiz, with his wonted sagacity, has ascertained to be the intestines of fishes; and has therefore named them *Cololites.* Although generally found insulated, specimens occur in which they are imbedded, like the coprolites of the Macropoma, in the abdominal region of fishes. The frequent occurrence of the *Cololites* apart from the body, is explained by the usual process of decomposition in fishes. M. Agassiz remarks that dead fish always float on the surface of the water with the belly uppermost, until the abdomen bursts from disten-

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* A full illustration of this remarkable fish will appear in Poiss. Foss. Tom. II.; but the lithographs do not do justice to the original drawings by Mr. Dinkel.

tion. The small intestines are then expelled by the evolved gases through the aperture, and soon become detached from the body. I have observed indistinct traces of similar remains in the beds of chalk in which fossil fishes most prevail. Dr. Buckland mentions the discovery, by Lord Greenock, of a mass of petrified intestines distended with coprolite, and surrounded by the scales of a fish, in a block of coal-shale from the neighbourhood of Edinburgh (*Bd.* p. 199.).

DERCETIS ELONGATUS. *Wond.* p. 335.—Before proceeding to the investigation of examples of the next order, I will describe a highly interesting Ichthyolite, which in a mutilated state is extremely common in some of the chalk strata of the South-east of England; it is noticed in *Foss. South D.* p. 232. This fish is placed by M. Agassiz in his family of ganoidians, termed *Scleroderms;* and he mentions that another species has been found in the chalk of Westphalia. The *Dercetis* has a very elongated body, with a short head terminating in a pointed beak; the upper jaw is a little longer than the lower, and both jaws are armed with long, conical, elevated teeth, and several rows of very small ones. On the sides of the fish there are three rows of osseous scutcheons like those of the Sturgeon (see *Wond.* p. 335.); the body was also covered with numerous small scales. From the form of the body somewhat resembling that of the eel, being very long, and subcylindrical in uncompressed examples, the specimens are generally called "*petrified eels*" by the quarry-men. The examples usually found consist of the elongated body, more or less compressed, and irregularly covered with patches of scales confusedly intermingled; among which, traces of the scutcheons may sometimes be distinguished. These specimens occasionally exceed two feet in length, by one or two inches in breath; with neither extremity perfect, and without any vestige of the fins. The example figured, *Wond.* p. 335, is the only instance in which I have seen either the head, vertebræ, or scutcheons; in one fragment only a fin remained.* These scutcheons in the Westphalian species have a prominent longitudinal ridge or keel, with the surface finely granulated; they are large enough to cover the whole body of the fish.†

FOSSIL CTENOID FISHES (*Poiss. Foss.* Tom. IV.).—The fishes of this order have imbricated laminated scales, the posterior margins of which are round and finely pectinated; *i.e.* divided into little teeth, like a comb. These scales are circular, but more or less elongated, and as the laminæ of which they are composed successively diminish from the lowermost to the uppermost, the pectinated margin of each being apparent, the surface is very scabrous; the front edge is sinuous. The common PERCH, is the

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* See Foss. South D. Pl. XL. fig. 2, and Pl. XXXIV. figs. 10 and 11.

† Poiss. Foss. *feuil. addit.* p. 20.

type of the Ctenoidians. The teeth of these fishes are invariably small, and either villous, or brush-like.

From the numerous fossil genera I select, in illustration of the characters of this order, the *Beryx*; of which three species occur in the Chalk. Of this genus, which is closely related to the Perch (*Perca*), two living species inhabit the seas of Australia. The bones of the skull have dentated crests; the dorsal fin has spinous rays in front, which are united to the soft rays; the margin of the caudal fin has little spinous rays.

BERYX LEWESIENSIS.* *Wond.* p. 337.—This is one of the most common of the Ichthyolites of the Chalk of the South-east of England; it is called "*Johnny Dory*" by the quarry-men; the specimens are from six to twelve inches long. The fossil figured in *Foss. South D.* Tab. XXXVI. was the first example of a tolerably perfect fish of any kind, that I obtained from the Chalk, after many years of research; although small patches of detached scales are very common. Many fine specimens have of late years been discovered at Lewes, Worthing,

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* This fish was first discovered and described by me, *Foss. South D.* Tab. XXXV. XXXVI., as ZEUS *Lewesiensis*; M. Agassiz has very properly referred it to the genus *Beryx*; but he has also substituted another specific name; which is wholly unwarrantable, for that first imposed ought to be retained: see p. 343.

Chatham, Maidstone, and in the Chalk of Westphalia. The outline of the perfect form of this species, *Wond.* p. 337, by Mr. Dinkel, conveys an accurate idea of its external characters. It has one dorsal fin with several spinous rays in front of the soft ray. The head is very large, and the opercular pieces are ornamented with sculptured rays; the margins of the jaws are covered with a broad band of brush-teeth. The orbit is large, and often contains the capsule (*sclerotica*) of the eye. The rays of the gills are short and thick, five are preserved in some examples. The scales are enormously large; about twenty-five in the median row; their posterior margins have several concentric rows of spines (see *Lign.* 126, fig. 3.). The lateral line is often distinctly apparent, in the form of a tube, contracted behind and expanded in the centre of the scale. The vertebral column is composed of large short vertebræ, armed with very long apophyses; the ribs are slight.

Beryx radians. *Wond.* p. 336—This species is smaller, and relatively longer, than the former; it generally occurs in the Chalk-marl, and is invariably of a very dark colour, the scales having a polished or glossy aspect. The scales are small, with a simple row of diverging spines on the posterior edge. The scales of the lateral line are peculiar; the mucous canal is not formed of a series of simple tubular cylinders, as in *B. Lewesiensis*, but is divided into several branches, as may be seen with a lens of moderate power. There are more than thirty scales in the length of the lateral line.

BERYX MICROCEPHALUS. (*Poiss. Foss.* Tom. IV. tab. 4[c].).—This fish is distinguished by its slender form, and the extreme smallness of the head, as the name implies. The scales have one row of very thick spines on the posterior margin; they are more elevated, and shorter than in *B. radians;* those of the lateral line are pierced by an elongated conical tube, and not ramified as in the last species.* This ichthyolite, like the *B. radians*, occurs in the Chalk-marl, and in a similar state of mineralization.

The fishes of this genus are the most ancient of the Perch tribe, and of the Ctenoid order. The three species above described are all at present known in the English Chalk; three other species have been found in the Chalk of Bohemia and Westphalia.

SMERDIS MINUTUS. *Wond.* p. 247.—A pretty ctenoidian fish, from one to three inches long, about the dimensions of a perch a year old, is very common in the marls of Aix in Provence; and many are often found grouped together in every variety of

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* A very beautiful example of *B. microcephalus*, discovered in the Chalk-marl at Clayton, near Hurstperpoint, is in the select collection of Frederick Harford, Esq., of Rutland-gate, Kensington.

position. This species is characterised by the elevated anterior rays of the dorsal, and the wide and very forked caudal fin.

Several ctenoidian and cycloidian fishes have been found in the north of the Brazils, by Mr. Gardiner, in strata probably of the Cretaceous epoch.

FOSSIL CYCLOID FISHES. *Poiss. Foss.* Tom. V.—This order comprises the fishes possessing scales of a cycloid, or circular form, with smooth margins, and composed of plates of horn or bone, without enamel. It contains numerous families, including the *Scaroids*, or Parrot-fishes; *Scomberoids*, or Mackerel tribe; *Lucoids*, or Pikes; *Clupeoids*, or Herrings; *Salmonoids*, or Salmon tribe; *Cyprinoids*, or Carps, &c. The fossil remains of this order are exceedingly numerous, particularly in the Tertiary and upper Secondary deposits. A genus of *Salmonidæ*, discovered in the White Chalk of Sussex, will serve to exemplify the characters of the fossil cycloidian fishes.

OSMEROIDES. Plate II. *Wond.* p. 133.—Two (if not three) species of this genus occur in the Chalk, near Lewes; and principally, if not exclusively, in the Lower Chalk, without flints. They are exceedingly beautiful Ichthyolites, and are almost invariably found with the body but little compressed; the fish, in many examples, is as round and perfect as when living. The entire cranium, the opercula, and branchial rays, and all the fins, are preserved in some examples. These fishes belong to the Salmon family,* and are nearly related to the SMELT (*Osmerus*); whence the name of the genus. There are two species, easily distinguishable. The first (*O. Mantelli*, Pl. II.) has a short, sub-cylindrical body, and seldom exceeds eight or nine inches in length; the other (*O. Lewesiensis*, *Wond.* p. 133.) has an elongated and elliptical body, and is from ten to twelve inches long.† The fossil figured in Pl. II. is a very remarkable specimen of the first species. It is nine inches in length; and the chalk has been cleared away, so as to expose the entire fish, six inches in relief above the surface of the block. The fish is lying on its back, with the mouth open, and the opercula, or gill-covers, and the branchial arches expanded; the pectoral and ventral fins, and the dorsal fin, are in their natural position; the five rays of the dorsal are erect; of the caudal fin, or tail, but slight indications remain. There is but one dorsal fin; but in a specimen of *O. Lewesiensis* there is a trace of the little adipose process observable between the dorsal fin and the tail, as in the recent species of *Salmonidæ*. A magnified view of one of the scales is represented *Lign.* 126, fig. 4, p. 594.

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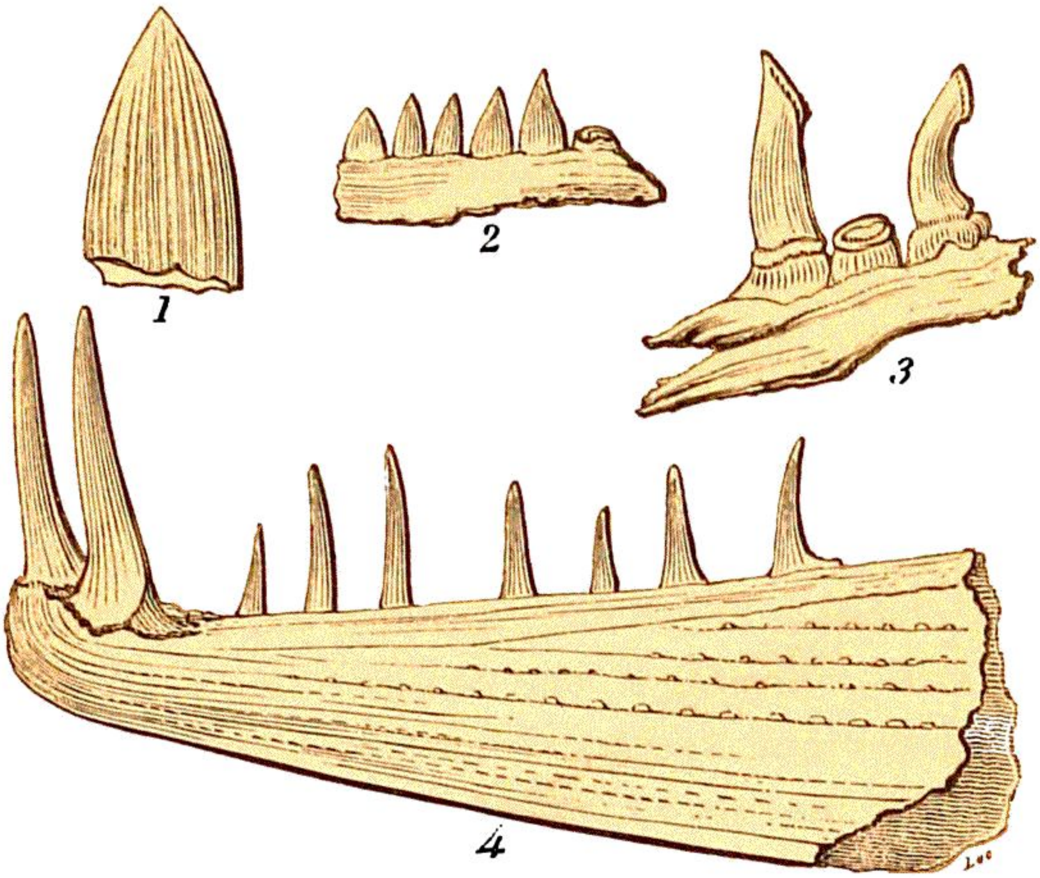
* They were first described, Foss. South D. p. 235, as *Salmo Lewesiensis*, Tab. XXXIII. and XL.

† There are other essential differences, but which require more figures for their illustration than our space will admit.

Of the CYPRINOIDS, or fishes of the Carp family, the recent species of which are inhabitants either of fresh-water, or the brackish waters of the mouths of rivers, many fossil species occur in the fluviatile and lacustrine deposits of the Tertiary formations. In their character of omnivorous fishes, the Carps then, as now, formed the principal mass of the finny population of the lakes, and in their turn served as food to the carnivorous tribes, as the pikes, eels, &c. Several species are found in a beautiful state in the schists of Œningen, and in the Tertiary marls at Aix. Many of the layers of marl at the latter locality are covered with groups of fishes of the family *Cyprinodonts*, the recent species of which are of a small size, and inhabit the fresh-water lakes of temperate zones. *Lign.* 125, p. 587, represents a portion of a large slab of marl in the cabinet of Mr. Murchison, which is covered with scores of a species resembling a recent fish (*Lebias*) in the profile of its head, and the form of its fins. It is named LEBIAS *cephalotes*, from the relative largeness of its head. The black appearance of the abdomen in many of these Ichthyolites indicates the original situation of the intestines, and of the liver, which is largely developed in the fishes of this family, and contains much colouring matter.

SAUROCEPHALUS AND SAURODON. *Lign.* 136.—In the same quarry, near Lewes, from which the first entire fish of the Sussex Chalk was obtained, teeth of a very peculiar character were, many years since, occasionally discovered.* These teeth are of a lanceolate form, much compressed, with entire




LIGN. 136. FOSSIL TEETH AND JAWS OF FISHES. *Chalk. Sussex.*

Fig. 1.—Tooth of SAUROCEPHALUS LANCIFORMIS. *Lewes.*
2.—Teeth of SAUROCEPHALUS STRIATUS. *Brighton.* Portion of the jaw, with five teeth.
3.—Fragment of a jaw, with two perfect teeth, and the base of another, of SAURODON LEANUS. *Kemp-town, Brighton.*
4.—ENCHODUS HALOCYON. Left branch of the lower jaw, with teeth; and one front tooth of the opposite portion. *Lewes.*

sharp edges, terminating in a point; the fang is single, and broad; the surface of the crown is glossy, and

* Foss. South D. Tab. XXXIII. p. 228.

marked with fissures filled with chalk (see *Lign.* 136, fig. 1.). Teeth of this kind, attached to portions of the jaw, were subsequently found in the Chalk at Brighton and Lewes. Similar remains were collected from the Cretaceous marls of Missouri and New Jersey, in the United States. The American specimens comprised two closely-allied genera, which, from the supposition that the fossils were the relics of reptiles, were respectively designated *Saurocephalus* and *Saurodon.** Examples of the teeth and jaws of both genera have been discovered in the Sussex Chalk (see *Lign.* 136.).

M. Agassiz retains the names imposed by the American naturalists, and has placed these genera in the family of Scomberoids (*Mackerel*). The teeth are disposed in a single row, and fixed in deep sockets by a simple root, or fang, which is frequently somewhat excavated by the pressure of a successional tooth. In *Saurodon Leanus* the crown of the tooth is angular, and barbed, and supported on a sub-cylindrical shank, or stem (see *Lign.* 136, fig. 3.). The microscopical structure of these teeth has been elucidated by Professor Owen;† it presents that peculiar reticulated disposition of the

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* American Phil. Trans. Vol. III. new series, Pl. XVI. on the *Saurodon*, by Dr. Hayes; and Journal Acad. Sciences, Philadelphia, Vol. IV. on the *Saurocephalus*, by Dr. Harlan.

† Odontography, p. 131, pl. 55.

medullary canals throughout the entire body of the tooth, which is only found in the dental organs of fishes.

ENCHODUS (*sword-tooth*) HALOCYON. *Lign.* 136, fig. 4. (*Poiss. Foss.* Tom. V. tab. 25c.)—The specimen figured is a portion of the lower jaw, with one row of elongated, conical, slightly curved, pointed teeth, the two anterior teeth being much longer and larger than the others; it affords a good illustration of the dental organs of *Enchodus;* a genus of fishes, the jaws and teeth of which are often found in the Sussex Chalk. The teeth are of various sizes, and attached by anchylosis, one row on the premandibular bone, and another irregular row of smaller teeth, to the inside of the lower jaw. The two anterior teeth are very large, and of a peculiar form: their base is wide and solid, and the shank of the tooth is suddenly contracted, immediately above, and becomes elongated into a point. These teeth are generally of a dark colour, have a glossy aspect, and are very brittle; differing so remarkably in this respect from the shark's teeth, with which they are usually collocated, that mere fragments can be readily identified. The external surface of the lower jaw is marked with finely granulated, longitudinal ridges or striæ.*

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* A fine example of the lower jaw, with twelve teeth, is figured *Foss. South D.* Tab. XLI., and another, with the upper jaw and teeth, *Geol. S. E.* p. 140.

HYPSODON LEWESIENSIS. (*Foss. South D.* Tab. XLII.)*—The Sussex and Kentish Chalk also contain the remains of a very large fish, with extremely upright, long, conical, compressed, pointed teeth, which, like those of the Saurodon, are implanted in sockets. These teeth are commonly of a delicate fawn colour externally, and of a dark brown internally; having a large simple pulp-cavity. In *Foss. South D.* (Tab. XLII.) are represented portions of an intermaxillary and jaw-bone with teeth; a vertebra, deeply biconcave; and a large bone, apparently a branch of the *os hyoides*; all found in the same block of chalk.†

ICHTHYOLITES OF RECENT SPECIES.—The distinguished naturalist to whose labours in fossil Ichthyology we have been so largely indebted, states, that of the many hundred species submitted to his notice, but one can be identified with any fish now living. This conclusion must, however, be received with some reservation; for, among the fossil genera, founded only on the teeth, there are species which certainly cannot be distinguished from recent forms. And in the diluvial drift at Breslau, associated with

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* A systematic catalogue, drawn up by M. Agassiz, of the fishes discovered by the author in the Sussex Chalk, will be found in *Wond.* pp. 425—428.

† A magnificent specimen (now in the British Museum) displays, on the same slab of chalk, a large portion of the cranium, teeth, several vertebræ, ribs, and many other bones, belonging to a fish of considerable magnitude.

the bones of the fossil elephant (*Elephas primigenius*), the remains of a pike, closely resembling the common European species, have lately been discovered.*

The exception above alluded to, is a little fish (*Mallotus villosus*), which inhabits the shores of Iceland; and fossil specimens occur in nodules of indurated marl or clay, along the coasts of that island. It is supposed that these Ichthyolites are of very recent date; and that similar fossils are in the progress of formation.†

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GEOLOGICAL DISTRIBUTION OF FOSSIL FISHES.—From the incidental notices of the geological habitats of the fossil fishes enumerated in our survey of this class of beings, the reader cannot fail to have remarked, that the most recent strata abounded in forms related to the inhabitants of the existing seas and rivers; while the most ancient teemed with species and genera of families altogether extinct, or of prodigious rarity in the recent fauna.

In general terms, it may be stated, upon the authority of M. Agassiz, that the Ichthyolites of the Tertiary deposits approach in their characters to the living genera, but all the species are extinct. The

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* Poiss. Foss.

† See Poiss. Foss. Tom. V. pl. 60, in which the skeleton of the recent fish, and specimens of their fossil remains, are represented.

newer Tertiary, as the Crag, contain genera common to tropical seas, as the large sharks (*Carcharias*), and eagle-rays (*Myliobates*), &c. In the Eocene, or most ancient Tertiary, as the London and Paris basin, Monte Bolca, &c. *one*-third of the Ichthyolites belong to extinct genera. Of the Chalk fishes, *two*-thirds are of extinct genera, but related to those of the Tertiary formations. From the Oolite to the Lias, including the Wealden, the fishes constitute a natural group, not one species of which occurs in the Chalk; and all the ganoid fishes are *homocercal*. Below the Lias, a prodigious number of unknown genera and species appear; and almost all are *heterocercal*.

Thus, of the eight thousand living fishes known to naturalists, three-fourths belong to the Cycloid and Ctenoid orders, and of these no species are known below the Chalk; the other fourth is referable to the Placoids and Ganoids, of which there are comparatively but few existing species. Yet fishes of these two orders almost solely flourished during the ancient secondary formations; for below the Lias, the predominant recent orders are altogether absent. Beneath the Coal true carnivorous fishes, with trenchant teeth, are almost unknown, but omnivorous species, with either brush or obtusely conical teeth, and great sauroid fishes, are the prevailing representatives of the class. In fine, the Ichthyolites of the different formations constitute two grand groups, which have their boundary line at the base of the Cretaceous deposits. The first and most ancient, comprises the Ganoids and Placoids; the second, more intimately related to existing types, comprehends forms more diversified; these are principally Ctenoid and Cycloid, with a small number of the two preceding orders, which insensibly disappear; and their few living analogues are very distinct from the ancient species. Now, although deductions of this nature may require to be modified with the progress of knowledge, yet the generalizations thus obtained are founded on so vast an accumulation of facts and observations, as to render it improbable that they will be materially invalidated by future discoveries; for they remarkably accord with the results derived from the investigation of the fossil remains of all the other classes of animals. The most modern deposits contain the remains of animals allied to the existing species; the most ancient, of forms altogether extinct, or of excessive rarity in the recent faunas. The discovery of existing species, or genera, in the most ancient strata, would modify, but not destroy, the inferences deduced from the facts hitherto obtained; and every geologist is prepared to find that such may be the case.

Thus of the Sharks, with triangular notched teeth, which are so common in the Tertiary formations, and were formerly unknown in the ancient Secondary, one representative has been found in the Carboniferous system (see p. 627.). But, if teeth of this type should hereafter be discovered in every Secondary deposit, the great preponderance of these fishes over the Sauroid in the Tertiary, and in the existing seas, would not be the less remarkable.

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ON COLLECTING AND DEVELOPING FOSSIL FISHES. —From what has been advanced, the reader will have obtained a general knowledge of the fossil remains of this class, that are likely to be met with in particular deposits. Thus, he will expect to find the teeth of large sharks and rays in the Tertiary clays and sands ; and skeletons and perfect specimens of numerous Ctenoid and Cycloid fishes in the laminated marls and fine limestones of the same formations. In the Chalk, with numerous teeth of sharks, he may discover splendid examples of Cycloid fishes; and, in the Wealden, gigantic Ganoidians. Passing to the ancient Secondary strata, the extraordinary buckler-headed and Sauroid fishes, will arrest his attention; and their vestiges be found, more or less perfect, in the nodules of indurated clay, and in the shales and limestones.

The detached teeth of fishes in Tertiary sands and clays may be easily obtained entire, and should be arranged in the same manner as the shells (see p. 443), either in trays, or on boards. The triangular teeth, with lateral denticles, must be carefully extracted, so as to preserve those appendages on which the specific and generic distinctions of many Ichthyolites depend. M. Agassiz particularly recommends the preservation of all the specimens collected together in the same locality, as many may probably belong to the same individual, and thus the dental organization of the original be determined. Teeth collected from the same stratum in different places, should not, therefore, be mixed together. Several series of the same kind of teeth should be preserved, and as many as possible of each kind; for specimens, apparently identical, may prove to be highly instructive as a series. I have often had occasion to regret the disposal of supposed duplicates, in my earlier researches, which would have tended to elucidate the characters of those specimens which were retained.

The Ichthyolites, and their detached teeth and fins, in the Chalk and other soft limestones, may be cleared by means of a penknife or graver, and small sharp chisels. It is preferable to leave the teeth attached to small blocks of the chalk; as in the examples, figured *Lign.* 130. But to develop the beautiful Chalk Ichthyolites, particularly those of the Salmon, Macropoma, &c., some practice and considerable dexterity are required. The compressed fishes, as the Beryx, like those in the Tertiary limestones, often lie in the sedimentary plane of the stone, and may be sufficiently exposed by a blow of a hammer or a pick, to show the nature of the fossil, and admit of being easily developed. But the fishes, with sub-cylindrical bodies, very commonly split asunder in a transverse direction; and those with spinous scales, as the

Macropoma, adhere so firmly to the chalk, that, to display the external surface of their scales, the surrounding stone must be removed piecemeal, in the manner described for the Chalk crustaceans (see p. 567.). The collector who sees the splendid Chalk fishes in the British Museum, and learns that they were found in the Sussex Chalk, will be grievously disappointed, upon visiting the quarries from which they were obtained, if he expects to discover specimens with any considerable portion of the scales, or body, exposed. It was many years before the quarry-men acquired the tact they now possess, of detecting, from very slight evidence, the presence of an Ichthyolite in a block of chalk.*

The fossil *Smelt* (see p. 664.), which may be considered as one of the most extraordinary of the Chalk fishes found in England, affords an excellent illustration of the mode of developing the Ichthyolites of this formation. This interesting fossil is delineated on a small scale, in three different states, in

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* Patches of scales, which the quarry-men called "*bran*," and detached shark's teeth "*birds' beaks*," and teeth of Ptychodus, "*slugs*," were the only remains of fishes obtained from the workmen around Lewes, for several years after I had commenced collecting the fossils of the South Downs; and it was only by stimulating their activity by liberal rewards, that they could be induced to persevere till they had acquired the art of detecting entire specimens. I believe my first Lewes Ichthyolite cost me its weight in gold, so much had been previously expended on insulated scales and teeth.

Plate II.; and affords a good practical lesson for the student and the young collector. Among some blocks of chalk containing fossils, which a recent fall in one of the quarries near Lewes had brought to light, was a large mass split asunder, and exposing, on each corresponding surface, an irregular oval marking of a yellowish brown colour; this appearance is represented Pl. II. fig. 1. Presuming that these markings were produced by a transverse section of the body of a fish, the two blocks were trimmed into a portable size, and accurately cemented together with very *hot*, *thin*, *fresh* glue. When consolidated, some of the chalk was chiselled off in the supposed longitudinal direction of the enclosed fish; and part of the body, covered with scales, was exposed, as Pl. II. fig. 2. With the view of ascertaining the extent of the Ichthyolite, some of the surrounding stone was then removed towards each extremity of the block, and traces of the fish were discovered, as shown in the same figure. The task of completely developing the fossil was thus rendered comparatively easy; the chalk was chiselled, cut, and scraped away, till the perfect fish, as seen in fig. 3, was developed.* The block was then

* The figure in Pl. II. is too small to convey an accurate idea of this Ichthyolite, which is now in the British Museum. M. Agassiz's figure very inadequately represents the original. A beautiful lithograph of this fish, by Mr. Pollard, of Brighton, was published in the Catalogue of the Mantellian Museum, 1836.

reduced to a convenient size, and the edges sawn smooth. The chalk is easily cut with a carpenter's saw; the instrument should be short and strong, and the teeth of moderate size.

When a *portion* of the body of an Ichthyolite of this kind is found in a block of chalk, and the fracture of the block appears to be recent, diligent search shonld be made for the corresponding piece; for it may probably be found to contain the other part of the fish. A splendid specimen of *Osmeroïdes Lewesiensis*, more than a foot long, was thus obtained. The quarrymen, in a block of chalk which a recent fall had thrown down, discovered a few inches of the caudal portion of the body of a fish; on the broken surface of the stone, a section of the body was distinctly seen; as in the specimen previously described. Search was made among the fallen masses for the corresponding piece, but without success. Upon observing the face of the quarry exposed by the recent fall, on a projecting block, many yards above our reach, a discoloured spot was indistinctly seen, and it was conjectured that this might prove to be the other moiety of the Ichthyolite. The workmen were directed to preserve this block if possible; but it remained *in situ* several months, and until the rock was again blasted; when the stone so long coveted, rolled away from the fallen mass, and fortunately was soon discovered. It proved to be the corresponding portion of the fish; with the head, opercula, branchial arches, pectoral fins, and the anterior part of the body covered with beautiful cycloid scales. In the preparation of fossils of this kind, glue as the cement, and a paste made of plaster of Paris with thin glue, to fill up the crevices and strengthen the block, are the materials I have employed. The fossil remains of fishes in other rocks, require to be extracted and developed in the manner previously directed for the Echinoderms, Cephalopoda, &c. (p. 358.)

The collector may be reminded, that *Otolithes*, or ear-stones (p. 603.), are found in the Crag of Norfolk, and other Tertiary strata; and that Coprolites, associated with minute scales, bones, &c., of small fishes, constitute, in some localities, layers of considerable thickness, and of great extent. The "*bone-bed*" of the Lias, near Westbury, Somerset, is a well-kuown example of such a deposit.

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MICROSCOPICAL EXAMINATION.—A few words on the microscopical examination of the remains of fishes may be useful. The structure of the large, and the forms of the minute scales, may be seen by a common lens, and without preparing the specimens. But for the examination of the intimate organization of scales, teeth, &c., the microscope is required; and the method directed for the investigation of flint should be employed. The scales, portions of the membranes of the stomach, &c., and thin chips of the teeth, rendered temporarily transparent by oil of turpentine, or permanently so by Canada balsam (see p. 246.), should be viewed by transmitted light. But the intricate structure of the dental organs, the medullary canals, and the calcigerous tubes, cannot be successfully investigated without the aid of the lapidary, or the adoption of the process described for the preparation of fossil wood (see page 78.) for microscopical exploration.

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## BRITISH LOCALITIES OF FOSSIL FISHES.

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*** The detached teeth, scales, vertebræ, &c. of fishes, are so extensively distributed, that there is scarcely a cliff or quarry of fossiliferous rock in Great Britain, that does not contain some examples. The following list of localities must, therefore, be regarded as merely directing the student to a few places, in which particular fossils of this class have been discovered.

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Abergavenny. *Mt. L.* Teeth of Psammodus, Orodus, &c.

Armagh, Ireland. *Mt. L.* Numerous teeth, &c.

Arundel, Sussex. *Cret.* Quarries in the neighbourhood; beautiful Chalk fishes.

Aust Cliff, near Westbury, Somersetshire. *Lias.* In a layer called the *bone-bed*, containing bones, scales, teeth, and Coprolites of fishes. Teeth of *Ceratodus*. (*Geol. Proc.* III. p. 408.)

Axmouth. *New Red; Bone-bed*, with numerous scales, bones, and teeth. *Saurichthys.*

Barrow-on-Soar. *Lias.* Dapedius.

Brighton. *Cret.* Chalk quarries in the vicinity. Beryx, Dercetis, *Saurocephalus*, *Saurodon*, and the common species of teeth, &c.

Bristol. *Mt. L.* The usual species of Psammodus, Orodus, Onchus, &c.

Burdie-house, near Edinburgh. *Carb.* Palæoniscus, Megalichthys, Holoptychus, &c.

Caithness, Scotland. *Magnesian Limestone.* Palæoniscus, and numerous species of allied genera.

Chatham, Kent. *Cret.* Beryx, Hypsodon, and the usual teeth, &c.

Cheltenham. *Lias.* In the *bone-bed* numerous teeth, scales, Coprolites, &c.

Clayton, Sussex. *Lower Chalk.* *Beryx microcephalus,* and other rare Ichthyolites.

Clifton, near Bristol. *Mt. L.* Teeth of Psammodus, Orodus, &c.

Cromarty, Scotland. *Old Red.* *Coccosteus, Pterichthys,* &c.

Cuckfield, Sussex. *Wealden.* Lepidotus, Hybodus, Acrodus.

Downton Castle. *Sil. Syst.* In a quarry on the banks of the Teme, a fish-bed composed of scales, teeth, and Coprolites, in Upper Ludlow limestone.

Downton Hall, near Ludlow. *Devonian.* Cephalaspis, Dipterus, &c.

Dudley. *Sil. Syst.* Ichthyodorulites, &c.

Dungannon, Ireland. *New Red.* Quarry at Rhone-hill; numerous Palæonisci, particularly of a small species; *P. catopterus.*

East Thickley, Durham. *Magnesian Limestone.* Palæonisci, several species.

Glammis, Forfarshire. *Devon.* Cephalaspis, Gyrolepis, Dipterus.

Hastings. *Wealden.* Lepidotus, Hybodus.

Leeds, Middleton Quarry. *Carb.* Layers of *fish-coal,* abundance of remains of Megalichthys, Holoptychus, &c. (*Geol. Proc.* III. p. 153.)

Lewes, Sussex. *Cret.* All the fishes of the British Chalk (See *Wond.* p. 425 ).

Lyme Regis. *Lias.* Dapedius, Hybodus, *Squaloraia;* and numerous other species and genera

Newhaven, near Leith. *Carb.* On the shore, nodules of ironstone with fishes and Coprolites. *Amblypterus,* Palæoniscus.

Sheppey, Isle of. *Tert.* Numerous teeth of Rays, Sharks, &c., and other Ichthyolites in great abundance.

Shotover, near Oxford. *Kimmeridge Clay.* *Chimæra,* Hybodus, &c.

Speeton, Yorkshire. *Galt.* *Macropoma Egertoni;* and many other fishes.

Steyning, Sussex. *Cret.* In the marl-pits, Coprolites and teeth of Sharks are abundant.

Stonesfield. *Oolite.* Hybodus, Lepidotus, Leptacanthus, &c.

Swanage. *Wealden.* Lepidotus, Hybodus.

Westbury, near Bristol. *Lias.* Bone-bed with numerous remains of fishes.

Worthing. *Cret.* Beautiful Chalk fishes in the neighbouring quarries.

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## FOREIGN LOCALITIES.

*** Although the present work is expressly designed as a guide to the British collector, I am induced to subjoin a few foreign localities of *Ichthyolites,* that lie within the reach of the continental tourist. A detailed account of the most celebrated sites, is given by M. Agassiz, *Poiss. Foss.*

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Aix, in Provence. *Tertiary.* Some of the beds of gypseous marl contain numerous species in abundance (p. 665.). See *Wond.* p. 245.

Eisleben, Upper Saxony. *New Red,* or *Zechstein.* Numerous Ichthyolites in dark shale.

Glaris, Switzerland. *Cret.* Immense numbers of fishes in dark schist. The specimens are often contorted, from the contraction of their bodies, during decomposition. See *Wond.* p. 338.

Maestricht (St. Peter's Mountain). *Upper Cret.* Numerous teeth, vertebræ, &c. of fishes of the Cretaceous epoch. See *Wond.* p. 297.

Mansfeld, in Thuringia. *New Red*, or *Zechstein.* Fishes in copper-slate, in great numbers; many extremely beautiful.

Monte Bolca, or Vestena Nova. *Tert.* The richest mine of Ichthyolites in the world. A catalogue of the numerous genera and species found in this celebrated locality, is given in *Poiss. Foss.* Tom. IV. pp. 33—52.* See *Wond.* p. 251.

Mount Lebanon, Asia. *Tert.* Numerous Ichthyolites, in great perfection.

Œningen. *Tert. fresh-water.* Many kinds of fishes of the same genera as those which inhabit the great European

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* It is necessary to caution the collector against the frauds practised by the quarrymen, and dealers in fossils, at this and other celebrated foreign localities. Specimens, apparently perfect, are ingeniously constructed from the fragments of various examples. The head of one fish, the body of another, decorated with the fins of a third, and perhaps the tail of a fourth, of different species, or even genera, are dove-tailed together, coloured, and varnished, so as to deceive the common observer, and, occasionally, even the experienced collector. Sponging the specimens with cold water will often detect the imposition; for the colour if artificial will be removed, or rendered paler; while the same process will heighten the natural tints. At Pappenheim, Solenhofen, and other places, where fossil crustaceans, as Shrimps, Prawns, &c. are found in such perfection, the *imprints* of good specimens are often coloured, and offered for sale; a wet sponge will speedily detect the imposture.

lakes; as the Perch, Salmon, Eel, Pike, Carp, &c. A list of these Ichthyolites will be found in *Poiss. Foss.* Tom. II. part 2, p. 78. See *Wond.* p. 250.

Saarbrück, in Lorraine. *Carb.* Amblypterus, and other Carboniferous fishes.

Seefeld, on the Tyrol; on the principal road from Inspruck to Munich. *Lias.* Abundance of fish in bituminous slate.

Stabia, Italy, at Torre d'Orlando, near Castellamare. *Oolite.* Beautiful fishes in fissile limestone.

Solenhofen. *Oolite.* Numerous Ichthyolites; many in great perfection. See *Wond.* p. 449.

# CHAPTER XVII.

## FOSSIL REPTILES; COMPRISING THE ENALIOSAURIANS AND CROCODILES.

"Nous remontons donc à un autre âge du monde; à cet âge où la terre n'étoit encore parcourue que par des reptiles à sang froid—où la mer abondoit en ammonites, en bélemnites, en térébratules, en encrinites, et où tous ces genres, aujourd'hui d'une rareté prodigieuse, faisoient le fond de sa population."—CUVIER, *Oss. Foss.* Tom. V. p. 10.

WE have now to investigate the fossil remains of the highest organized classes of the animal kingdom, which possess an osseous skeleton, with a flexible spinal column, composed of articulated bones, and present in the various classes, orders, genera, and species, innumerable modifications of form and structure. The mineralized relics of these organisms consist, for the most part, of insulated or displaced groups of bones, teeth, &c., and durable portions of the dermal integuments; entire skeletons being of extremely rare occurrence. A profound knowledge of anatomy and physiology, and access to anatomical and zoological collections, are therefore indispensable for the successful cultivation of this department of Palæontology. Fortunately for the

English student, this most interesting branch of the science, which a few years since was but little regarded in this country,* has been greatly advanced, by the liberal support afforded by the British Association of Science to the labours of Professor Owen; whose Reports on the British Fossil Reptiles and Mammalia, published in the Transactions of the Association, are alike honourable to their distinguished author and to the Institution, and render it wholly unnecessary to enter at large upon the organic remains of these grand classes of the animal kingdom. Our remarks will, therefore, be restricted to a very general notice of the mineralized relics of Reptiles, Birds, and Mammalia; and descriptions of such characteristic examples, as will serve to illustrate the nature of the fossil remains, that may probably be presented to the notice of the collector.

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* It is not twenty years since the publication of the "*Fossils of Tilgate Forest,*" which contained numerous figures of the bones of the Wealden reptiles, previously unknown. Of this work, although eulogized by the illustrious Cuvier, with that kind and generous bearing towards every cultivator of Palæontology, however humble, for which he was as much distinguished as for his surpassing genius, not fifty copies were sold. At that time there was not an articulated skeleton of a crocodile in the Hunterian Museum, and but very few skeletons of any other reptiles, to which access could be had for comparison with the fossil bones; and many of the latter were repeatedly taken to the College of Surgeons, to compare with recent bones, without obtaining any clue, even to the place they held in the skeleton.

At the same time, the reader desirous of more precise information on these topics, will be directed, by numerous references, to sources from whence the required instruction may be obtained.

THE AGE OF REPTILES.*—The announcement of the illustrious founder of Palæontology, in the quotation prefixed to this chapter, that there was a period when the lakes, rivers, and seas of our planet were peopled by reptiles, and cold-blooded oviparous quadrupeds, of appalling magnitude, were the principal inhabitants of the dry lands, was a proposition so novel, and startling, as to require the authority of the name of CUVIER, to obtain for it any degree of credence; even with those, who were prepared to admit that a universal deluge could not account for the physical changes, which the crust of the earth had evidently undergone. Subsequent observations and discoveries have, however, fully confirmed the truth of this induction, and the

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* "*The Age of Reptiles*" was the title given by the author to a popular summary of the evidence bearing on this question; it was published in the Edinburgh Philosophical Journal, 1831. This name is now generally employed to designate the geological epochs characterised by the predominance of oviparous quadrupeds. This unpretending paper brought upon the author an attack by the Rev. J. Kirby, in the Seventh Bridgewater Essay; and the absurd and unjust strictures of the reverend essayist are retained in a recent edition! Upon this, as upon a former occasion, I am content to refer the reader to Dr. Buckland's invaluable volumes. See *Wond.* p. 500.

"*Age of Reptiles*" is now no longer considered fabulous.

In the most ancient fossiliferous deposits, indications of the existence of Reptiles are visible, in the indelible markings left by their footsteps on the muddy banks of rivers, and on the wet sands of the sea-shores, now in the state of layers of marl and sandstone. Here and there, in the Carboniferous and New Red systems, teeth and bones are found presenting unequivocal proofs of the early presence of extinct forms of cold-blooded oviparous quadrupeds. As we ascend in the secondary formations, we are suddenly surrounded by innumerable marine and terrestrial reptiles, belonging to species and genera of which no living representatives are known. Throughout the Liassic, Oolitic, Wealden, and Cretaceous epochs, the class of Reptiles was at its fullest development. In the Tertiary periods which succeeded, the Reptiles approached the recent types, and their relics are found intermingled with the bones of mammiferous quadrupeds; thus indicating the commencement of the present condition and relations of the animal kingdom. Referring the reader to *Bd.* p. 165, and *Wond.* pp. 480—504, for a more comprehensive view of this subject, we advance to the examination of some of the fossil genera and species; and propose, in the first place, to explain a few essential characters of form and structure, observable in those durable parts of the skeletons of reptiles, which are most frequently met with in a fossil state; namely, the teeth, jaws, vertebræ, &c.; and the osseous appendages of the dermal system.

It will, perhaps, be useful to premise, that the animals comprehended in the class of Reptiles, may, in a very general sense, be said to constitute four principal divisions; namely—

The *Chelonians*, or Tortoises; which have a heart with two auricles; the body supported by four feet or paddles, and enveloped in two osseous bucklers, composed of the expanded bones of the sternum and thorax.

The *Saurians*, or Lizards; having a heart with two auricles; the body supported by four or two feet, and covered with scales.

The *Ophidians*, or Serpents; the heart with two auricles, and the body destitute of feet.

The *Batrachians*, or Frog-tribe; the heart with one auricle; the body naked, with only rudimentary ribs; and with two or four feet. Most of these reptiles breathe by branchiæ or gills in their young state, and by lungs in the adult (as for example the Frog); in some (the *perenni-branchiata*), the branchiæ are persistent through life.

Teeth of Reptiles.—The teeth of the animals of this class exhibit considerable diversity of form, but the characteristic type is that of a conical, pointed tooth, with a simple root or fang; for, *in no reptile does the base of the tooth terminate in more than one fang, and this is never branched.* "Any fossil, therefore, which exhibits a tooth implanted by two fangs in a double socket, must be mammiferous, since the socketed teeth of reptiles have but a single fang; and the only fishes' teeth which approach such a tooth in form, are those with a bifurcate base, belonging to certain sharks."*

These dental organs are only fitted for seizing and retaining the prey or food; for no living reptiles have the power of performing mastication. In the Crocodiles the tooth has a cylindrical shank, with a conical, longitudinally striated, enamelled crown, having a ridge on each side (Pl. VI. fig. 5.). In the *Labyrinthodon* (a fossil reptile), the cone is more curved and pointed (Pl. VI. fig. 3.); in the *Hylæosaurus*, the shank is cylindrical, and the crown expanded and lanceolate, with blunt margins (Pl. VI. fig. 6.); in the *Megalosaurus* the tooth is laterally compressed, trenchant, and bent backwards like a sabre, with serrated edges (Pl. VI. fig. 7.); in the *Iguanodon* the shank is cylindrical, and the crown of a prismatic form, greatly expanded, with broad denticulated edges, and longitudinal ridges in front (Pl. VI. fig. 4, and *Lign.* 142.). In the Serpents, the teeth are very long and pointed; in the Crocodiles and Lizards, may be seen every modification of the conical form, down to a mere hemispherical tubercle or plate.† The Turtles are *edentulous*, i.e. destitute of teeth; their dental organs, consisting of the horny trenchant sheaths with which the jaws are covered.

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* Prof. Owen; Odontography, p. 25.

† Odontography, pl. 66, fig. 6.

The teeth are very numerous in reptiles; the individuals of some species have more than two hundred. In some genera, they are implanted on the jaws alone; in many, they occupy the palatine, vomerine, and other bones composing the vault of the mouth, as in certain fishes. They are generally anchylosed to the bone; but in some genera are implanted in distinct sockets, as in the Crocodile and Plesiosaurus; in others, as in the Ichthyosaurus, they are arranged in a deep furrow, and retained only by the integuments. In some, they are supported upon an elevated osseous base, as in the Mosasaurus (*Wond.* p. 299.), and in another remarkable reptile of the Chalk, named *Leiodon* (*Odont.* pl. 72.). In the Labyrinthodonts, and in the greater part of the Serpent tribes, the tooth is implanted by the base in a shallow socket, with which it is confluent.* But in most of the Lacertians, or true Lizards, the attachment of the teeth presents a peculiar modification, of which the lower jaw of the Iguana, *Lign.* 137, p. 693, affords a good illustration. These teeth are not placed in sockets, but attached by the shank to an alveolar plate, or parapet, that extends along the margin of the jaw, as shown in figs. 1 and 3; the crowns of the teeth project above this plate, as seen in figs. 2 and 4. From the anchylosis of the teeth to the side of

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* Odontography, p. 182.

the jaw, the Lizards possessing this dental structure, are termed *Pleurodonts*.*

In reptiles, we have, therefore, five essential modifications in the attachment of the teeth; namely, in distinct sockets; in a continuous groove or furrow; attached laterally by the shank to an alveolar parapet; anchylosed by the base to a shallow socket; and attached to an osseous support, without sockets or an alveolar plate.†

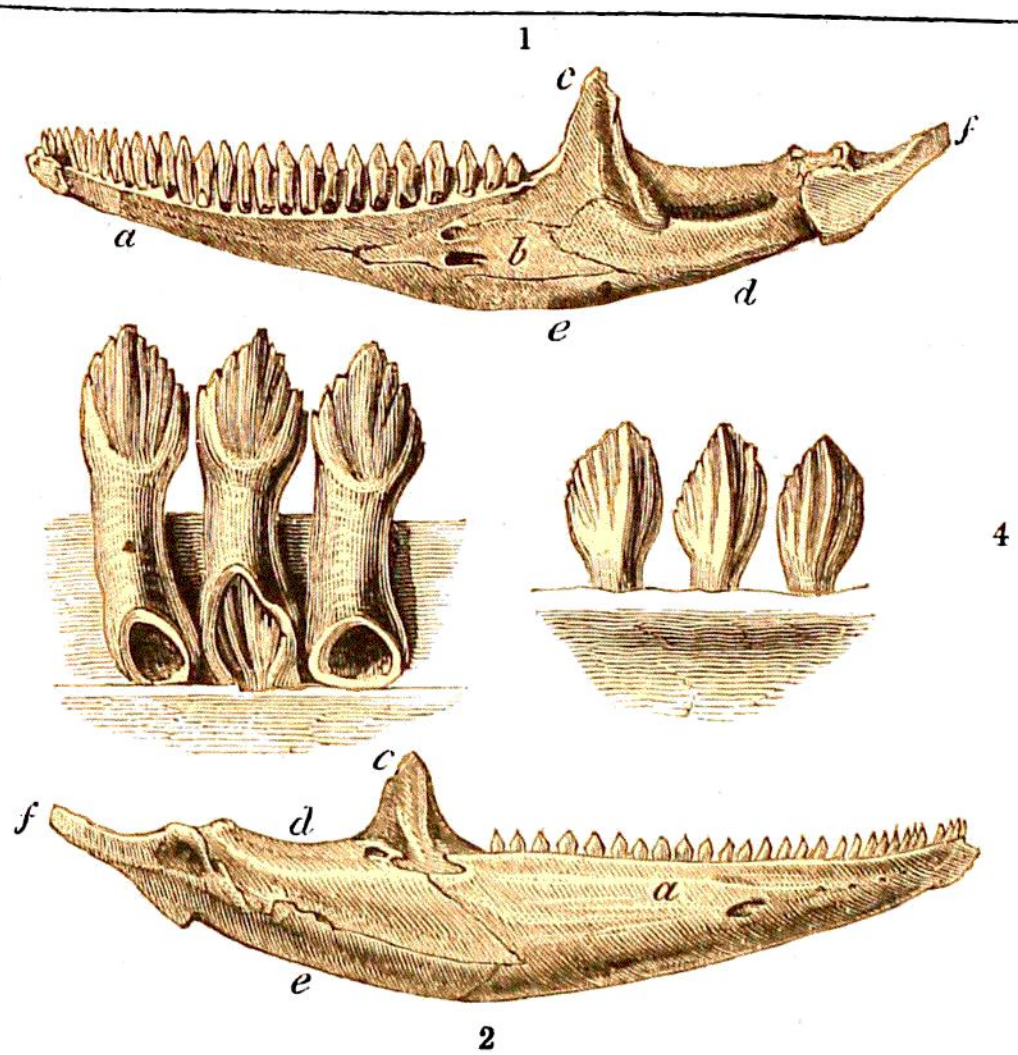
The intimate structure of the teeth of reptiles, as demonstrated by Professor Owen, consists of a simple pulp-cavity, surrounded by dentine, which is permeated by extremely minute calcigerous tubes, radiating at right angles to the periphery, or external surface of the tooth. One essential modification of this structure, according to the same eminent observer, consists in the intermingling of cylindrical processes of the pulp-cavity in the form of medullary canals, with the finer tubular structure; as in

* The *Pleurodonts* are those lizards in which the teeth are anchylosed to the side of the dentary bone; *Acrodonts (summit-teeth)*, those with the teeth fixed to the upper margin of the jaws: *Thecodonts*, those having the teeth anchylosed to the walls of the sockets.

† See the beautiful exemplification of this subject, and the comparison between the transitory stages of the human teeth in their progress of development, discovered by Mr. Goodsir, with the permanency of these conditions in reptiles. Odontography, p. 182.

the tooth of the Iguanodon, Pl. VI. figs. $4^b$, and $4c$. But another modification is that to which allusion was made when describing the teeth of the Lepidosteus (see p. 651.); in this mode, the dentine preserves its normal character, but the external cement and surface of the tooth are deeply inflected in longitudinal folds around the entire circumference; and this structure is accompanied with corresponding extensions of the pulp-cavity and dentine into the interspaces of these inflected and converging folds. This organization is shown, in its simplest form, in the transverse section of the base of a tooth of the Ichthyosaurus, Pl. VI. fig. 9; and attains its most complicated condition in that of the Labyrinthodon, Pl. VI. figs. $3^a$, $3^b$, $3^c$.

On the mode of development of the teeth, we must briefly state, that the germ of the new tooth is always produced at the side of the base of the old one; that in its progress of growth it presses against the tooth it is destined to supplant, occasions the progressive absorption of the fang, and ultimately displaces its predecessor; in some instances, by splitting the crown of the tooth; in others, by casting it off, according to the oblique or direct position it attains in its progress, in relation to the old tooth. Thus, in the teeth of the Crocodile, we generally find the new tooth immediately under the conical apex of the crown; and beneath the former, a second successional tooth (*Wond.* p. 385), like a series of thimbles of various




LIGN. 137. THE LOWER JAW OF AN IGUANA.

*(Presented by the late Baron Cuvier.)*

Fig. 1.—The right branch of the lower jaw of an IGUANA, from Barbadoes, viewed on its inner aspect: *nat.*

*a.* Dentary bone.
*b.* Opercular bone.
*c.* Complementary bone.
*d.* Surangular bone.
*e.* Angular bone.
*f.* Articular bone.

2.—The external aspect of the same.

3.—Inner aspect of three teeth *(magnified)* attached to the alveolar parapet; with the germ of a successional tooth at the base of the middle tooth; and the sockets of other germs at the bases of the two fully formed teeth.

4. External view of the crowns of three teeth; slightly magnified.

sizes placed one upon another; for in reptiles the production of new teeth is unlimited. But in the *Pleurodont* lizards, the new tooth makes its way obliquely, and the crown is often shed entire. *Lign.* 137, fig. 3, exemplifies the situation of the successional teeth in the Iguana.

LOWER JAW OF REPTILES.—It is well known that the lower jaw in mammiferous animals, is composed of a single bone on each side; and that in many genera, these pieces become united in front, and form but one bone in the adult state. But in reptiles, the lower jaw consists of six distinct bones on each side, as in *Lign.* 137; and these undergo various modifications of form and arrangement in the different genera. These bones are distinguished by names which have reference to their office and situation, and are as follow—*Lign.* 137, *a*, the *dentary* bone, supporting the teeth; *b*, the *opercular; c*, the *complementary; d*, the *sur-angular; e*, the *angular; f*, the *articular*, which forms the upper portion of the jaw, and includes the condyle. The form and disposition of these bones in the Iguana, and other true Saurians (*lizards*), are shown in *Lign.* 137; but they differ materially in the Crocodile, Ichthyosaurus, and other genera. We must restrict our comments to this short notice, which, however, will suffice to enable the collector who discovers a fragment of a lower jaw, with any traces of the structure above described, to determine that it is reptilian; and if any portion of the *dentary* bone remain, indications may be obtained of the family, and perhaps genus, to which it belonged.*

VERTEBRÆ OF REPTILES.—The bones of the vertebral column of this class of animals, present such numerous and important modifications in the different orders and families, that reference to the works already cited must be made, for satisfactory information on this topic. From the great number of vertebræ in many reptiles, amounting in the individuals of some species to nearly two hundred, these bones are, perhaps, the most abundant fossil relics of these animals to be found in our collections. The vertebræ are commonly detached, and deprived of their processes; the solid *centrum*, or body, alone remaining in most examples (as in *Lign.* 138, fig. 8.). Connected series, more or less complete, are occasionally discovered; and the entire column, in connexion with other parts of the skeleton, is preserved in many of the specimens in the British and other museums. Although, for the reasons previously stated, osteological details cannot be attempted in the present volumes, some acquaintance with the

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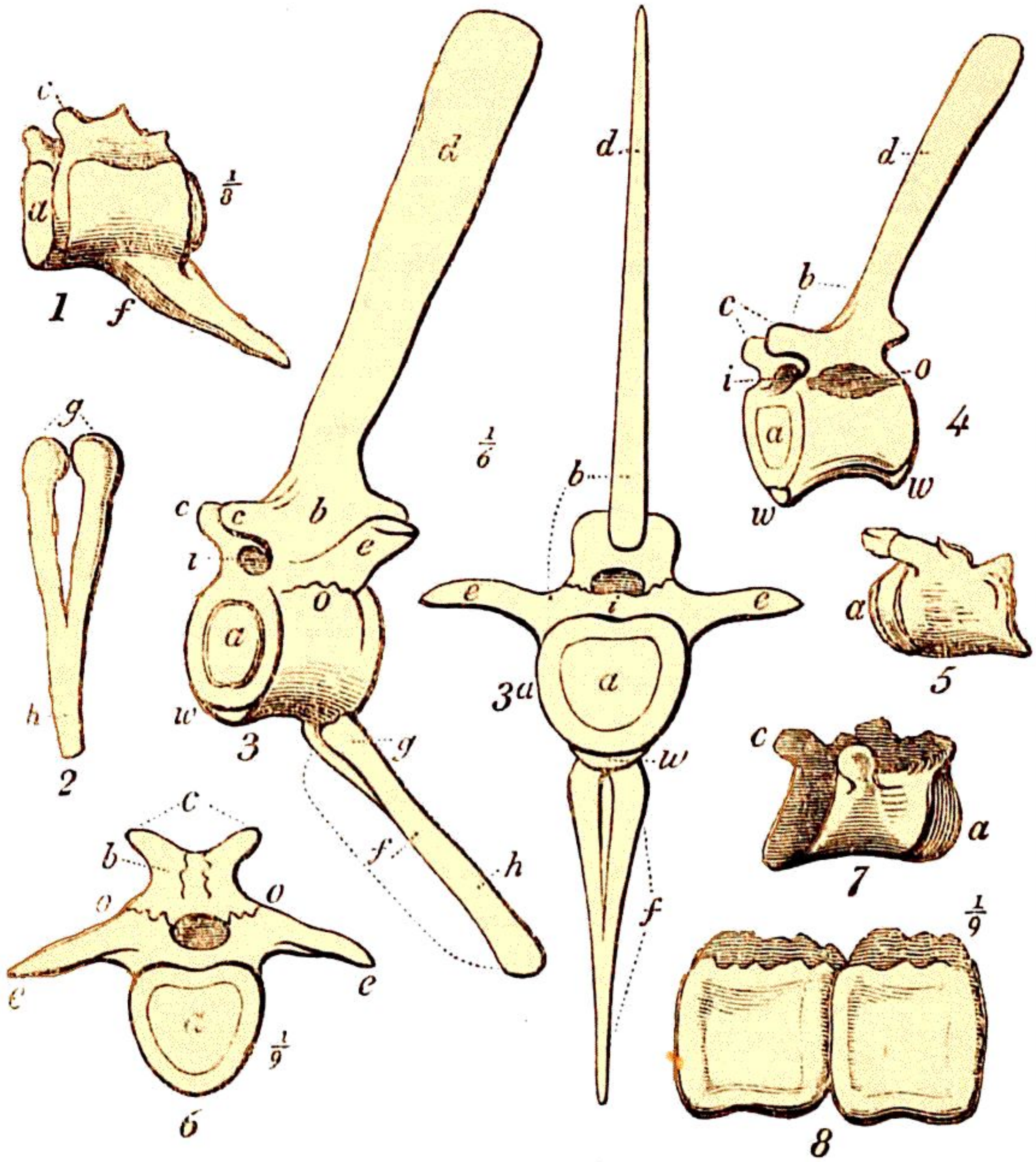
* To obtain a correct knowledge of the osteological structure of fossil Reptiles, the student should consult Baron Cuvier's *Ossemens Fossiles*, Tom V., and Professor Owen's Reports to the Brit. Assoc. for 1839 and 1841. To the English reader, the translated abridgment of Cuvier's "Fossil Remains of the Animal Kingdom," by E. Pidgeon, Esq. 1 vol. 8vo, with plates, 1830, will be found a very instructive volume. See also Penny Cyclopædia, art. *Saurians*.

elementary characters of the vertebræ of reptiles is necessary to guide the student, and even the amateur collector, in their researches. I have, therefore, selected a few specimens from Tilgate Forest in illustration of the elements of Saurian vertebræ, and will explain the terms by which the different processes or parts are distinguished; the general reader will thus be enabled to comprehend the descriptions of these structures in other works on Palæontology.

The bones composing the spine, are not only designed to form a flexible column of support to the trunk, but also to afford protection to the grand nervous chords constituting the spinal marrow, and which extend from the brain to the tail, and give off numerous lateral branches in their course; conferring sensation and motive power to every part of the frame. To effect this purpose, there is attached to the upper, or external face of each vertebra, a bony ring, called the *annular* part, or *neural-arch*, which is composed of two processes (*Lign.* 138, *b.*), arising from each side of the body, or *centrum* (*Lign.* 138, *a.*), and which unite above into a solid piece, termed the *spinal* process (*Lign.* 138, *d.*). On each side of the annular part there is a process, called the *transverse* (*Lign.* 138, *e*, *e.*), for the attachment of muscles; and, in some reptiles, as the Crocodiles, these processes are articulated to the ribs. The vertebræ of the tail have, in addition to the above apophyses, an inferior spinous process, termed the *chevron-*




LIGN. 138. FOSSIL VERTEBRÆ OF REPTILES. *Tilgate Forest.*

(*The figures are reduced in the proportions specified by the fractions.*)

Fig. 1.—Caudal vertebra of an unknown reptile.

2.—Chevron bone of IGUANODON: seen in front.

3.—Caudal vertebra of IGUANODON, viewed laterally in an oblique direction.

3a.—Front view of the same.

4.—Caudal vertebra of IGUANODON, without either transverse process or chevron-bone. The letter *o* marks the deep hollow left by the removal of the transverse process, at the suture of the annular part.

*Fig.* 5.—Vertebra of STREPTOSPONDYLUS: $\frac{1}{10}$ *nat.*

6.—Lumbar vertebra of IGUANODON, with the spinous process broken off.

7.—Vertebra of STREPTOSPONDYLUS: $\frac{1}{10}$ *nat.*

*c.* The pair of *posterior* oblique processes.

8.—The bodies of two dorsal vertebræ of IGUANODON: viewed laterally.

The same letters refer to the same parts in the respective figures, with the exception of *c* in fig. 7.

*a.* The body, or *centrum*, of the vertebra: the letter denotes the anterior part.

*b.* The annular part (*neurapophysis*), which contains the spinal chord.

*c, c.* The articular processes, which join to the next vertebra in front.

*d.* The spinous process of the annular part.

*e, e.* The transverse processes of the annular part.

*f.* The chevron-bone (*hæmapophysis*), or inferior spinous process of the vertebra.

*g.* The double articulating head of the chevron: the passage left by these processes, as seen in the front view, fig. 2, is for the passage of the large blood-vessels which supply the tail.

*h.* The spine of the chevron-bone.

*i.* Denotes the medullary cavity of the annular part.

*o, o.* Mark the sutures which connect the annular part with the body of the vertebra.

*w. w.* Indicate the place of attachment of the chevron-bone.

bone (*Lign.* 138, fig. 2 and fig. 3, *f.*), which gives support to the inferior layers of the caudal muscles; and bifurcating at its attachment to the body of the vertebra, leaves a channel for the passage of the large blood-vessels, by which the circulation of the tail is effected.

In the generality of living reptiles (as, for example, in the Crocodile) the bodies of the vertebræ are concave in front, and convex behind; the bones of the spine being united by ball and socket joints;

but, in most fossil reptiles, both faces are either flat, or more or less concave. In quadrupeds, the annular part is anchylosed to the vertebral centre; but in reptiles, it is united by suture, although, in old subjects, the connecting line is often obliterated. By reference to *Lign.* 138, and its description, the form, arrangement, and connexion, of the different vertebral elements, in certain fossil reptiles, may be easily comprehended. The bones in the vertebral column of the same animal are considerably modified in the several regions of the neck (*cervical* vertebræ), back (*dorsal*), and tail (*caudal*). The cervical are generally of the most complicated structure; and the caudal, the most simple. From this exposition, the reader will perceive that every vertebra consists of the following essential parts: first, the body, or *centrum;* and secondly, the annular part, or *neurapophysis*, so named, because it protects the nervous chord; while a caudal vertebra has, in addition, the *chevron-bone*, called also *hæmapophysis*, from its affording a passage to the large blood-vessels. The bodies of the vertebræ are in general solid, and consist of the ordinary osseous structure; but in certain fossil vertebræ the centre of the bone is filled with calcareous spar, indicating an irregular medullary cavity.

The *Sacrum*, which may be termed the key-stone of the pelvic arch, is formed by the union of two or more vertebræ. In the Iguanodon and the Megalosaurus, the sacrum consists of five anchylosed vertebræ, as Professor Owen first demonstrated.*

In the Crocodiles, the four or five vertebræ preceding the sacrum have no ribs attached to them, and are, therefore, termed *lumbar;* in the Lizards, there are but two lumbar vertebræ. A peculiar modification exists in the first caudal vertebra of the adult Gavial and Crocodile; the *centrum* is *convex* both in front and behind. The last of the anchylosed vertebræ forming the sacrum, is concave posteriorly; hence the necessity of an anterior ball in the first joint of the tail (see *Wond.* p. 797, fig. 153.). The last *cervical* vertebra in the Turtles and Tortoises has a similar construction. This mechanism confers freedom of motion without risk of dislocation.†

The *Ribs*, which are regarded as appendages to the vertebræ, are generally slender and round in the Lizards, with a single head, supported on a short convex process or tubercle. But in the Crocodilians, and several fossil reptiles, the head of the rib is double; and the posterior ribs are attached to the elongated transverse processes of the verte-

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* Brit. Assoc. Reports for 1841, p. 130 and p. 105.

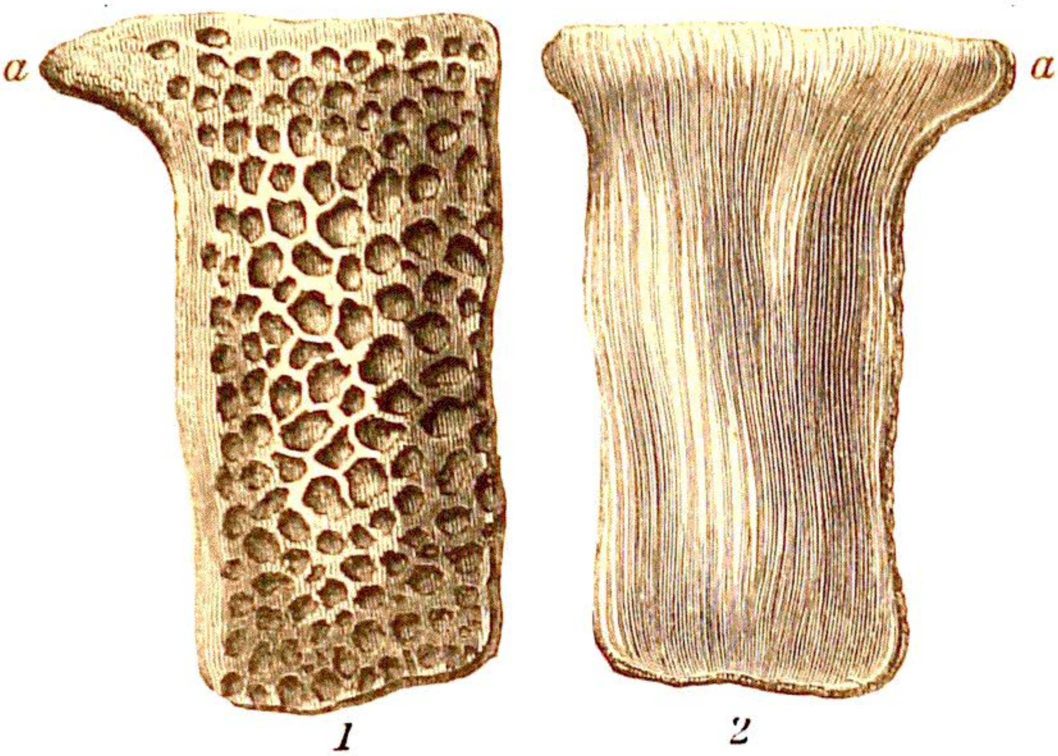
† The importance of a knowledge of this fact to the collector is too obvious to require remark; the discovery of a doubly convex caudal vertebra in the strata of Tilgate Forest, would, I confess, have been very perplexing before my detection of this peculiarity in the skeleton of a Gavial in the museum of Dr. Grant, the eminent Professor of Comparative Anatomy in University College.

bræ. In some reptiles the ribs are flat and broad. The locomotive extremities in reptiles are variously constructed according to the adaptation of the animals to a terrestrial, fluviatile, or marine existence. The bones of the limbs in the extinct colossal terrestrial species, closely resemble those of our large pachydermata, the Rhinoceros and Hippopotamus (see *Lign.* 143.). The cylindrical bones of the extremities in the Crocodilians, and other recent reptiles, are solid, *i.e.* have no cavity filled with marrow; but the thigh-bones and leg-bones of the Iguanodon, and other extinct land reptiles, have a medullary canal; this modification of structure renders the limbs better adapted for walking. Our limits will not admit of further osteological details; and we are compelled to omit the description of the bones composing the pectoral and thoracic arches.*

DERMAL BONES. *Lign.* 140. In some of the reptile tribes, particularly of the Crocodilian or loricated *(mailed)* group, the external integument or skin contains numerous osseous *scutes*, or scutcheons, variously arranged, and which serve as supports to the integumental scales and spines. In the gigantic Gavial, that inhabits the Ganges, and other rivers of India, and which is remarkably distinguished from the common Crocodile and Alligator by its extremely slender muzzle, which is prolonged into a beak, the nape of the neck is

* See Brit. Assoc. Report, 1841.

covered with dermal scutes, consisting of sixteen or eighteen transverse rows; and there are six longitudinal series, which extend down the back. These bones are corrugated or pitted on their upper surfaces; a structure adapted for the firm adhesion of the scaly integument. Detached bones possessing this character often occur in the Wealden strata;




LIGN. 139. DERMAL BONE OF THE SWANAGE CROCODILE: $\frac{1}{3}$ *nat.* *Wealden.*

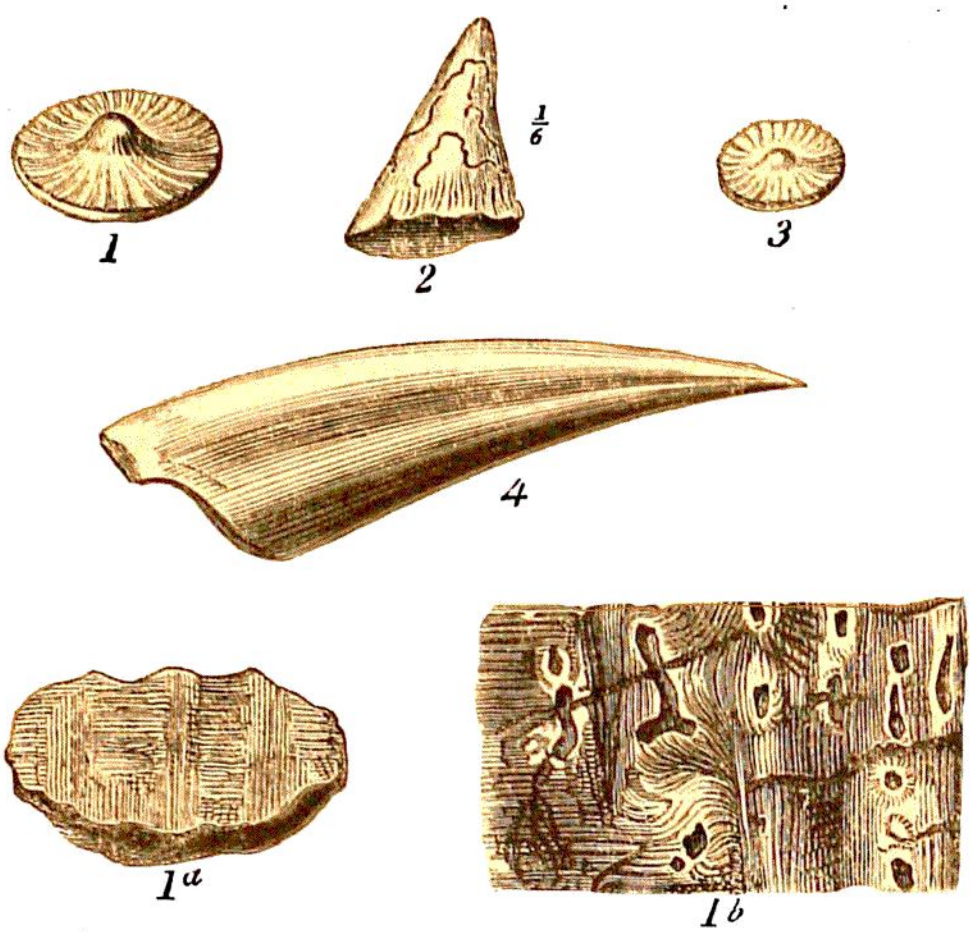
(GONIOPHOLIS CRASSIDENS.)

Fig. 1.—The external aspect.
2.—The inner surface.
*a.* The lateral connecting process.

and the first fragments found were supposed by me to belong to the soft-skinned turtles *(Trionyces)*;

but the discovery of perfect scutes, demonstrated their analogy to the dermal bones of the Gavial. In the splendid specimen of the fossil remains of a Crocodile *(Goniopholis)*, found at Swanage (*Wond.* p. 387.), there are numerous *scutes* of this kind dispersed among the bones, as shown in *Wond.* Pl. I. One of these dermal bones is figured *Lign.* 139; fig. 1, represents the external surface, which is irregularly covered with numerous deep, round, or angular pits or excavations; fig. 2, the inner surface. These scutes differ from those of all known recent and fossil Crocodilians, in possessing a lateral conical projection (marked *a*, figs. 1, 2, *Lign.* 139.), which fits into a depression on the under surface of the opposite angle of the adjoining plate; resembling, in this respect, the scales of the Lepidotus (see *Lign.* 132, p. 638.). Numerous hexagonal and pentagonal scutes, articulated together by marginal sutures, also entered into the composition of the osseous dermal cuirass of this reptile, which must, therefore, have possessed a flexible, yet impenetrable, coat of armour, capable of affording protection against the attack of any assailant. The under surface of these scutes is smooth; but there are numerous very fine lines decussating each other at right angles, as in the dermal bones of the Hylæosaurus (*Lign.* 140, fig. 1[a].).

In the Oolite, the dermal bones of another slender-nosed Crocodilian *(Teleosaurus)* are occasionally met with; the outer surfaces of which are marked with small circular distinct pits; these scutes are thicker and more rectangular than those above described,




LIGN 140. DERMAL BONES OF REPTILES. *Tilgate Forest.*

Fig. 1, and 3.—Dermal bones of the HYLÆOSAURUS: $\frac{1}{3}$ *nat.*

1a.—The under surface of a fragment of a *dermal bone*, displaying fine spicula, decussating each other at right angles, and indicating a similar structure to that of the *Corium*, in which the bones were imbedded: *nat.*

1b.—A portion of the same, highly magnified, and viewed by transmitted light.

2.—HORN of the IGUANODON: $\frac{1}{6}$ *nat.*

4.—A DORSAL SPINE of the HYLÆOSAURUS; the original is thirteen inches long.

and must have overlapped each other laterally; they have no connecting process. In another species, one half of the outer surface is smooth, proving that it was covered to that extent by the adjoining scute.*

Elliptical and circular dermal bones, having the under surface flat, and the upper convex, with a conical tubercle, were first noticed in the specimen of the *Hylæosaurus*, figured *Wond.* Pl. IV.; and I have since discovered similar scutes associated with other remains of that extraordinary reptile; reduced figures of two specimens are represented in *Lign.* 140, figs. 1, 3.

The structure of these bones is very remarkable; upon closely inspecting the under side, or the surface exposed by a transverse fracture, very minute osseous spicula, decussating each other at right angles, are distinctly seen; as shown in *Lign.* 140, fig. 1[a]. In fig. 1[b], a thin slice of the same, highly magnified, and viewed by transmitted light, displays medullary canals, with very fine lines radiating from them. The peculiar character of this organization consists in the disposition of the straight bony spicula; an appearance which first attracted my attention when developing the original specimen of the Hylæosaurus (see *Geol. S. E.* p. 327.), and led to the discovery of some perfect bones, which otherwise would have been destroyed. This structure closely resembles that presented by the ligamentous

* A full description of the dermal bones of all the British fossil reptiles will be found in Brit. Assoc. Report for 1841.

fibres of the *corium*, or skin, and seems to have resulted from an ossified condition of the dermal integument. These bones vary from half an inch to three or four inches in diameter, and were disposed in one or more longitudinal series on each side the spine, diminishing in size as they approach the end of the tail.

DERMAL SPINES. *Lign.* 140. fig. 4.—With the dermal bones above described there are associated in the Hylæosaurus, flat, thin, angular, osseous plates, from three to seventeen inches in length; one of which is figured *Lign.* 140. fig. 4. The manner in which they are imbedded in the first discovered specimen of the Hylæosaurus, is shown *Wond.* Pl. IV. and *Geol. S. E.* Pl. V. These very remarkable processes appear to me to have formed part of a serrated fringe, which extended along the back of the reptile, analogous to that observable in certain living lizards (*Wond.* p. 402.).*

* The attention of the collector of Wealden fossils should be particularly directed to the discovery of some of these bones, in natural juxtaposition with other parts of the skeleton; for Professor Owen, although admitting the probability of my conjecture, suggests that they should rather be regarded as abdominal ribs: but it appears to me, among other reasons, (such, for example, as the unusual thickness of the spinous process of the dorsal vertebræ,) that the circumstance of these bones never occurring in pairs, and no two agreeing either in size or form, is unfavourable to such a hypothesis. See Prof. Owen's Remarks on the Dermal Spines of the Hylæosaurus; Brit. Rep. 1841, p. 115.

In this category may be placed the nasal tubercle or horn of a saurian, like that of the Iguana (*Lign.* 140, fig. 2; *Geol. S. E.* Pl. III.), found with the remains of the Iguanodon, and probably belonging to that colossal reptile (*Wond.* p.400.). It is four inches in length and 3.2 inch by 2.1 inch in diameter at the base, which is of an irregular, elliptical form. A smaller specimen has also been discovered.

We now proceed to offer a brief review of some of the principal genera of Fossil Reptiles, especially of those whose remains occur in the British strata; and we shall adopt the arrangement of Professor Owen, for the convenience of reference to those able reports, which will amply reward the most attentive perusal, and must be consulted by the student who would acquire a correct view of this department of Palæontology. The subject will therefore be considered under the following heads; namely:—

I. *Enaliosaurians*, or Marine Reptiles; Ichthyosaurus and Plesiosaurus.

II. *Crocodilian* Reptiles.

III. *Dinosaurians;* comprising the Iguanodon, Megalosaurus, and Hylæosaurus.

IV. *Lacertian* Reptiles; including the Mosasaurus.

V. *Pterosaurians;* the Pterodactyles, or flying Reptiles.

VI. *Chelonians*, or Turtles.

VII. *Ophidians*, or Serpents.

VIII. *Batrachians*, or the Frog tribe, comprising the Labyrinthodonts.

I. ENALIOSAURIANS. — The extinct marine reptiles comprised in this order, constitute two genera, which are characterised by essential modifications of osteological structure; they are named ICHTHYOSAURUS (*fish-lizard*), and PLESIOSAURUS (*akin to a lizard*). The general appearance of these beings is so well known, from the splendid collection of their fossil remains in the British Museum, and the numerous specimens in provincial and private collections, and by various works, both scientific and popular, in which their structure and physiological relations are fully elucidated, that they must be familiar to every reader.*

The living Ichthyosaurus must have borne a resemblance to a Grampus or Porpess, with four large flippers or paddles, and a long tail, having a vertical caudal fin, of moderate dimensions; the skin being naked and smooth, as in the Cetaceans. The Plesiosaurus must have presented a configuration still more extraordinary. With a very small head,

* *Bd.* Vol. I. and II. contain an admirable exposition of their habits and organization; and Brit. Assoc. Rep. 1839, an elaborate osteological investigation of both genera. A folio volume on these extinct Reptiles, with splendid lithographs, by Thomas Hawkins, Esq., cannot fail to delight the reader by its graphic descriptions, and beautiful illustrations.

it possessed a neck of enormous length, a body of moderate size, with four paddles, resembling those of turtles, and a very short tail. They were both marine, air-breathing, cold-blooded, carnivorous, vertebrate animals; swarming in prodigious numbers during the secondary epochs, and particularly in the seas of the Liassic period. In both genera the construction of the skeleton presents many important variations from all known recent types; and should be carefully investigated by the student, who will find in the Reports of Professor Owen all the information that can be desired.*

It will suffice for our present purpose to point out a few important and obvious characters.

In the Ichthyosaurus, the nasal apertures or openings of the nostrils are not towards the snout, as in the Crocodile, but near the anterior angle of the orbit, approaching, in this respect, some of the recent lizards. The orbit is very large, and the sclerotic coat, or capsule of the eye, has, in front, an annular series of bony plates (*Bd.* pl. 10, figs. 1, 3.), which often occur in their natural position.† This structure is not possessed by fishes, but is analogous to that observable in the eyes of turtles, lizards, and many birds; as for example, in the owl and eagle: it confers on the eye additional power of adapta-

* The Penny Cyclopædia, Art. PLESIOSAURUS, contains an able abstract of these Reports.

† The osseous plates of the sclerotica are beautifully displayed in many of the specimens in the British Museum.

tion and intensity of vision. The muzzle of the Ichthyosaurus is long and pointed; the lower jaw is formed of two branches, united anteriorly through nearly half their length; each branch is *composed of six bones*, as in the Crocodile and Lizards, but differently arranged than in those reptiles. The teeth are very numerous, amounting to nearly two hundred in some species, and are placed in a single row on each side the jaws, being implanted in a deep continuous groove (see *Bd.* pl. 11.). These teeth are of a pointed conical form, longitudinally striated, with an expanded base. The new teeth are developed at the inner side of the base of the old, and grow up and displace them. The microscopical structure of the teeth of the Ichthyosaurus is beautifully illustrated by Professor Owen (*Odontography*, pl. 64.). The tooth consists of a pulp-cavity, surrounded by a body of dentine, which is invested at the base by a thick layer of cement; and at the crown by a coat of enamel, also covered by a pellicle of cement; the pulp-cavity, in fully-formed teeth, is more or less occupied by coarse bone.* The chief peculiarity of this structure consists in the inflection of the cement into vertical folds at the base of the tooth, by which the marginal portion of the basal dentine is divided into a corresponding number of processes; producing, in a transverse section, the appearance represented in Pl. VI. fig. 9.† This organization, as we have

* Odontography, p. 275.

† This figure is reduced from Odontography, pl. 64.

previously remarked, is similar to that observable in the teeth of the *Lepidosteus* (see p. 651.), and of the extinct reptile, called *Labyrinthodon*, hereafter to be noticed.

The vertebræ (*Bd.* pl. 12.), of which there are upwards of one hundred and forty in the individuals of some species, are relatively very short in their antero-posterior diameter (*i.e.* from front to back); and deeply cupped on each articulating face, as in those of fishes. The annular part is not united to the body of the vertebra, as in quadrupeds, nor connected by suture, as in Crocodiles, but terminates on each side in a compressed oval base, which fits into corresponding sockets placed on the boundary line of the spinal depression on the body; thus completing the medullary canal (see *Bd.* pl. 12, fig. D, E.). Thus the collector may easily recognise the body of an Ichthyosaurian vertebra, by the pits or depressions on the sides of the spinal interspace. The first and second vertebræ are anchylosed together, and have additional sub-vertebral, wedge-shaped bones, which render this part of the column a fixed point of support.* (*Bd.* pl. 12, figs. 3, 6.). The form and arrangement of the bones that enter into the composition of the pectoral and pelvic arches, and of the paddles, are exemplified in *Bd.* pl. 12; and the osteological details, in *Brit. Assoc. Rep.*

* This structure was first demonstrated by Sir Philip Egerton. See Geol. Trans. Second Series, Vol. V. p. 187, Pl. XIV.

1839, p. 104. The bones of a fore-paddle of an Ichthyosaurus are represented, *Wond.* p. 489. In some species each paddle consists of nearly one hundred bones. These locomotive extremities are very analogous in their osteological construction to those of the Cetaceans, but they are connected with the trunk by means of the glenoid socket formed by the *scapula* and *coracoid*, which are firmly united to the sternum; whereas in the Cetaceans the pectoral fin is only attached to a simple scapula, which is merely suspended in the muscles.* This structure, together with the presence of a clavicle in the Ichthyosaurus, which is wanting in the Cetaceans, indicates, in the opinion of Professor Owen, that this marine fish-lizard was capable of some degree of locomotion on the land; and that it might have resorted to the shore to deposit its eggs, or, like the Crocodile, to sleep. From a dislocated state, or abrupt bend of the vertebral column of the tail, about one-third its length from the end, supposed to have been produced by the weight of a large fin, during the progress of decomposition; and from the terminal caudal vertebræ being laterally compressed, it is inferred that the Ichthyosaurus had a vertical fin at the extremity of the tail, which would thus be rendered a powerful instrument of progressive motion.† From the appearance of the Coprolites, which occur abundantly

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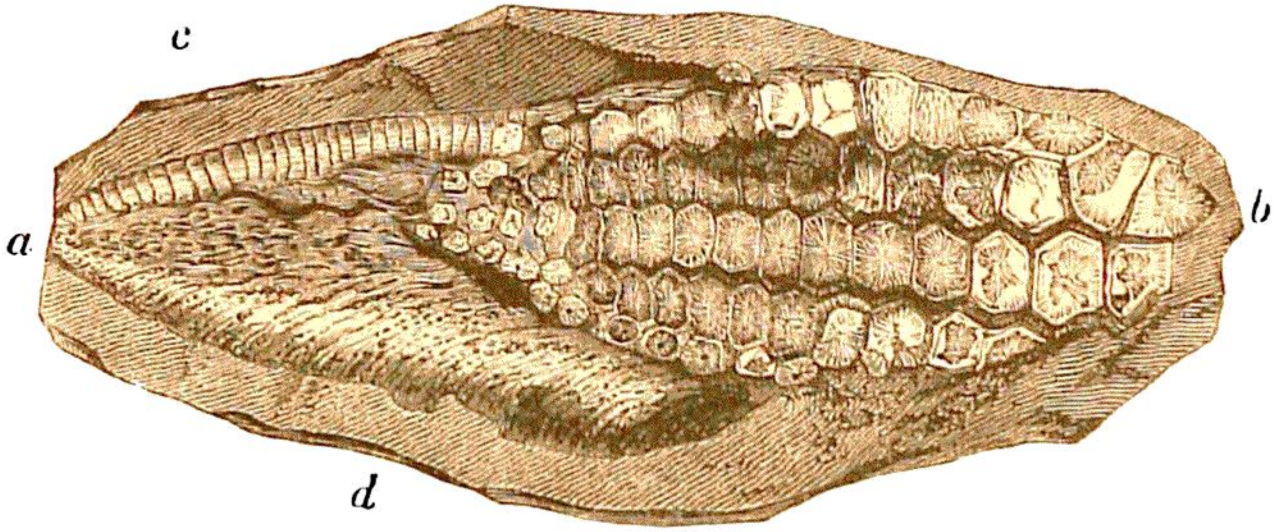
* Brit. Assoc. Rep. p. 104.

† Geol. Trans. Vol. V. Pl. XLII.

with the skeletons of these animals, it is obvious that the intestinal canal in the Ichthyosaurus was spirally convoluted, as in certain fishes. The dermal integument is preserved in some examples (see *Bd.* pl. 10.), by which it has been ascertained that these animals had a naked skin.




LIGN. 141. HINDER PADDLE OF AN ICHTHYOSAURUS ($\frac{1}{3}$ *nat.*); with its integuments. *Lias.* Barrow-on-Soar. (*From Geol. Trans. Vol. VI. Pl. XX.*)

INTEGUMENTS OF THE PADDLE.—The importance of carefully examining the surrounding stone before removing vegetable or animal remains from the matrix in which they are imbedded, and which has so often been insisted upon in the preceding pages, is strikingly exemplified in the highly interesting example of the hinder paddle of an Ichthyosaurus (*I. communis*), discovered by Sir Philip Egerton. *Lign.* 141 is reduced from the exquisite representation of the specimen accompanying the original memoir on this fossil, in the Geological Transactions. The specimen consists of the phalangeal bones of a posterior paddle, with the soft parts or integuments lying together in their natural position; *a*, marks the termination or distal extremity of the fin, consisting entirely of the carbonized integuments; these gradually widen and expand to receive the terminal rows of the phalangeal ossicles or bones, marked *b*. The upper border of this integumentary part of the paddle (*c.*) is formed by a smooth, well-defined line, apparently a mere duplicature of integument. But the lower margin (*d.*) exhibits the remains and impressions of a series of rays, by which the fold of integument was supported; and these rays bifurcate as they approach the margin of the fin. Professor Owen infers that these processes were either cartilaginous, or like the albuminous, horny tissue, composing the marginal rays in the fins of Sharks. The Lias at Barrow-on-Soar, appears to have been peculiarly adapted to the preservation of the more perishable parts of animal tissues; for Dr. Buckland detected the dermal integument of an Ichthyosaurus in a specimen from that locality (*Bd.* II. p. 22, pl. 10.); and in a fine skeleton with the four paddles, which I obtained from Barrow, there were decided traces of the carbonized integuments around each paddle, but which were, unfortunately, chiselled away, in developing the bones.

PLESIOSAURUS.* (*Bd.* pl.16—19. *Wond.* p. 490.). — The animals of this genus present in their

* Brit. Assoc. Rep. 1839, p. 50.

osteological structure a remarkable deviation from all known recent and fossil reptiles; uniting the characters of the head of a lizard, with the teeth of a crocodile, to a neck of inordinate length, with such modifications of the ribs, the pectoral and pelvic arches, and the paddles, as to justify the graphic simile of an eloquent Professor, that the Plesiosaurus might be compared to a serpent threaded through the shell of a turtle. The character which immediately strikes the observer, is the extraordinary length of the neck, and the relative smallness of the head. The neck, which in most animals is formed of but five vertebræ, and in the extremest recent example, the Swan, does not exceed twenty-four, is in the Plesiosaurus, composed of from twenty to forty vertebræ; and, in some species, is four times the length of the head, and equal to the entire length of the body and tail; while the length of the head (in *P. dolichodeirus*) is less than one-thirteenth of the entire skeleton. The skull resembles that of the crocodile in its general form, but is relatively smaller; the breathing apertures are situated anterior to the orbits on the highest part of the head. The lower jaw has the usual structure of the Saurians; but the dentary bone is greatly expanded anteriorly, and united in front (see *Bd.* pl. 19.). The teeth are implanted in separate sockets, as in the crocodile, and there are from thirty to forty on each side the jaws. They are conical, slender, long, pointed, slightly recurved, and longitudinally grooved from the base upwards; having a long round fang. The pulp-cavity is long and single, surrounded by a body of firm dentine, covered on the crown with a layer of enamel, and at the base with cement (*Odont.* pl. 74.). The dentition in the Plesiosauri differs from that of the Crocodiles, in the successional teeth emerging through distinct apertures on the inner side of the sockets of their predecessors, and not through the pulp-cavity (*Odont.* p. 282.). The vertebræ are relatively longer than in the Ichthyosaurus, and their articular faces are either flat, or slightly excavated towards the periphery, with a gentle convexity in the centre (*Foss. Til. For.* pl. 9, fig. 4.).*

The *pectoral arch* is remarkable for the pair of elongated and broad coracoid bones (*Bd.* pl. 17.); the *ribs*, which are very numerous, and extend throughout a great portion of the vertebral column, are connected, anteriorly, in the abdominal region, by several slender bones, called *costal arcs*, consisting of six or seven pieces to each pair of ribs; the Ichthyosaurus has a similar structure, but the arcs are composed of but five pieces. As these connecting bones are so constructed as to admit of a certain degree of gliding motion upon each other, it is inferred that, by this mechanism, considerable expansion of the pulmonary cavities in these air-breathing marine reptiles was obtained (*Bd.* pl. 18, fig. 3.).

* For details, see Brit. Rep. 1839, p. 50.

The paddles are composed of fewer and more slender bones than in the Ichthyosaurus, and must have been of a more elegant form, and possessed greater flexibility. The wrist (*carpus*) consists of a double row of round ossicles, which are succeeded by five elongated metacarpal, and these by slender and slightly-curved finger (*digital*), and phalangeal bones (*Wond.* p. 489.).*

Sixteen species of Plesiosaurus and ten of Ichthyosaurus, are described by Professor Owen, from the British strata; their geological range is from the Lias to the Chalk, inclusive. Their remains are found most abundantly in the Lias, and Oolite. I have collected many plesiosaurian vertebræ in the Wealden, and in the Green Sand of Faringdon. No traces of Ichthyosauri have been observed in the Wealden; but vertebræ, and jaws with teeth, occur in the lower Chalk and Galt of Kent and Cambridgeshire. On the Continent the remains of Enaliosaurians have also been discovered in the same geological formations.

Pliosaurus.—This name is employed by Professor Owen to designate a gigantic extinct reptile, of which the upper and lower jaws, with teeth, and considerable portions of the vertebral column, and many bones of the extremities, have been discovered in the Kimmeridge clay of Oxfordshire and Northumberland, and are preserved in Dr. Buckland's

* Brit. Rep. 1839, p. 56.

museum. The teeth resemble those of the Plesiosaurus in their general aspect, being of a conical form, and longitudinally grooved, and having a long fang; but they are readily distinguished by the subtrihedral form of the crown, produced by the smooth, flat, or slightly convex external surface; approaching in this respect the tooth of the Mosasaurus; from the latter, however, even fragments may be known by the presence of longitudinal ridges. The original was an enormous marine reptile, allied to the Plesiosaurians, but more nearly related to the Crocodilians.*

II. Crocodilians. — The loricated, or mailed Saurian reptiles, the Alligators, Crocodiles, and Gavials, are well known as the largest living forms of cold-blooded oviparous quadrupeds. No relics of any recent species have been observed in a fossil state; but remains of Crocodilians of the existing generic type, having the spinal column composed of concavo-convex vertebræ, (*i. e.* united to each other by a ball and socket-joint), the convexity being behind, or towards the tail, have been found in the Eocene deposits at Hackney, the Isle of Sheppey, on the coast of Western Sussex, and other localities of the London clay. But the Crocodiles of the Wealden, Oolite, and Lias, differ materially in their osteological characters from the recent species, particularly in the structure of the vertebral column;

* Brit. Assoc. Rep. 1841, p. 60. Odont. pl. 68.

which in one genus is composed of concavo-convex vertebræ placed in a reversed position to those of the existing species, the ball or convexity being *anterior*, or *directed* forwards. In the other genera, both the articular faces of the vertebræ are either flat, or concave.* (*Geol. S. E.* p. 296.).

In general terms, it may be stated that of the Crocodilians with broad muzzles, as the Cayman, and Alligator, no representatives have been found below the Tertiary formations; those of the Secondary deposits being all referable to the division having elongated beaks, like the recent Gavials (***Bd.*** p. 250.). The fossil Crocodiles of the latter type are arranged in two genera; namely, ***Teleosaurus*** (***Bd.*** pl. 25.), in which the nasal apertures terminate in two orifices, (not blended into a single opening as in the recent species,) in front of the nose; and ***Steneosaurus*** (***Bd.*** pl. 25, fig. 3.), in which the breathing canals end in two nearly semicircular vertical openings at the extremity of the muzzle.

The British fossil species, most nearly related to the recent, occurs in the London clay of the Isle of Sheppey, and of Bracklesham Bay. Two fine skulls have been found in the former locality (***Bd.*** pl. 25.); and a group of vertebræ in the latter (***Brit.***

* Cuvier, Oss. Foss. Tom. V. p. 153; on the fossil Crocodiles of Honfleur, which comprise both the types alluded to in the text.

*Rep.* 1841, p. 67.) of the recent concavo-convex type. A fine cranium of this Crocodile (*C. Spenseri*) is in the collection of the British Museum.*

In the strata of Tilgate Forest, associated with innumerable remains of reptiles of various genera, teeth of the Crocodilian type, belonging to two genera of Saurians, are not uncommon. They are figured and described in my *Illust. Geol. Sus.* These teeth were referred by Baron Cuvier to two species of the genus *Crocodilus;* but the discovery of a considerable portion of the skeleton of a reptile with the lower jaw containing teeth of one of these species; and of detached vertebræ of a peculiar form, associated with the other modification, has led to the establishment of two sub-genera.† The first kind is a tooth about an inch in length, of a slender acuminated form, compressed laterally, and gently recurved, with a sharp edge in front, and behind; resembling, in its general figure, the tooth of a Megalosaurus, with the serrations on the edges worn off (Pl. VI. fig. 7.). The sides of the crown are marked with a few longitudinal grooves. Some biconcave vertebræ found in the same quarries, and

* While writing this notice, I am informed by Mr. E. Charlesworth, (late editor of the Magazine of Natural History) that the skull of an *Alligator* has recently been discovered in a Tertiary deposit in one of the Eastern counties of England.

† Brit. Rep. 1841, p. 69.

characterised by the compressed wedge-shaped form of the centre (*Foss. Til. For*. pl. 9, fig. 11.), are supposed by Professor Owen to belong to the same reptile as the teeth, and described by him as *Suchosaurus* cultridens;* † but it is hazardous to pronounce on the identity of detached teeth and bones, without more corroborative proof of their identity.

SWANAGE CROCODILE. (*Goniopholis crassidens.*) *Wond.* Pl. I.—Under this name, the second species of Crocodilian teeth will be considered; the discovery of a considerable portion of a skeleton of the reptile with teeth of this form (*Wond.* p. 388.), having disclosed the most important osteological characters of the original. These teeth are distinguished from the former by their cylindrical base, and rounded, obtuse conical crowns: they somewhat resemble in form those of the Crocodile, but the crown is strongly marked with sharp, numerous, well-defined longitudinal grooves and ridges; and there is a sharp ridge on the middle of each side. A small specimen, broken off at the base, is represented Pl. VI. fig. 5; it shows the smooth cylindrical base of the tooth, which is covered with cement, and the finely striated enamelled crown;

* *Suchosaurus* is, I presume, derived from *Suchus*, or *Suchis*, the name given by Strabo to the sacred crocodile of the Egyptians.

† Brit. Rep. p. 68.

some of the teeth are more than two inches in length, and one inch in diameter at the base (*Foss. Til. For.* pl. 5, figs. 1, 2.). I have found these teeth in numerous localities; they are always well preserved, with the ridges sharp, and have a high polish; a series of successional teeth may often be detected in the pulp-cavity (see *Wond.* p. 385.). The detached teeth, and fragments of dermal bones (*Lign.* 139.), which, from their constant occurrence with this species, I had been led to consider as belonging to the same reptile, were the only relics that had come under my observation, until the discovery, by Robert Trotter, Esq., in the Swanage limestone, of the splendid specimen, of which one slab is figured *Wond.* Pl. I. On this, and the corresponding moiety, are imbedded many detached teeth; a portion of the left side of the lower jaw with two teeth in place; ribs and numerous vertebræ, which are biconcave, and have an irregular medullary cavity in the centre of the body; chevron bones resembling those of the Crocodile; the bones of the pelvic arch, and some of those of the extremities. With these are the remains of the osseous dermal cuirass, consisting of numerous scutes (figured and described p. 702, *Lign.* 139.) scattered at random among the other relics of the skeleton; some having the inner, and others the external surface exposed; several of these bones are perfect, and exceed six inches in length, and two and a half in breadth. Numerous scales of a small Ganoid fish (*Lepidotus minor*), common in the Purbeck strata, are also intermingled with these remains. This reptile is named *Goniopholis* (in allusion to the peculiar angular dermal scutes) *crassidens*, by Professor Owen.*

The remains of another genus of Crocodilian reptiles, having, like the Goniopholis, biconcave vertebræ, with a large medullary cavity in the middle of the centrum, occur in the Oolite of Caen, in Normandy. The body of the vertebræ is contracted in the middle, the neural arch anchylosed, with no trace of suture, and with a thin spinous process, which is remarkable for its backward inclination. Vertebræ of this character also occur in the strata of Tilgate Forest.†

TELEOSAURUS. *Bd.* pl. 25.—In the Oolite of England and the Continent, the remains of a genus of extinct reptiles having, like the recent Gavial, long slender muzzles, have been discovered in

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* Brit. Rep. 1841, p. 72. Both the slabs of the Swanage specimen are admirably arranged in the same case in the British Museum, with bones and scutes of this reptile from Tilgate Forest; there can be no doubt that the entire lower jaw of the Swanage reptile might have been obtained if the quarrymen had taken the precaution of examining the adjoining block of stone.

† This reptile is named *Poikilopleuron Bucklandi*, by the French savant, M. Deslongchamps, by whom its characters were first determined. See Prof. Owen, Brit. Rep. 1841, p. 84.

several localities. These fossils consist of the osseous scutes of an imbricated dermal cuirass; of the cranium and jaws with teeth; of the vertebral column, and many other bones. The characters of the dermal scutes, and of the muzzle with its terminal nasal apertures, have already been described (p. 703, and p. 719.). There are several species of *Teleosaurus;* a splendid specimen of *T. Chapmanni*, fifteen feet long, from the Lias-shale on the Yorkshire coast, is preserved in the Whitby Museum; and there are interesting examples in the British Museum. In the Oolite of Caen, in Normandy, very fine specimens have been discovered; and from these the illustrious Cuvier first determined the character and affinities of the original.* The British Oolite also contains the relics of a reptile with biconcave vertebræ, belonging to the genus *Steneosaurus:* the cranium with the jaws and teeth have been found in Kimmeridge clay, at Shotover (*Bd.* pl. 25.).†

From the Jura limestone at Manheim, in Franconia, and from Boll, in Wirtemberg, the remains of a small Crocodilian reptile (*Crocodilus priscus*), with a long slender muzzle, have been obtained. In a specimen, from the former locality, the skull, jaws with teeth, the entire vertebral column, and many

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* Oss. Foss. Tom. V. p. 127.

† Brit. Rep. 1841, p. 82.

parts of the skeleton are preserved: the entire length is but three feet.*

STREPTOSPONDYLUS, *Lign.* 138, figs. 5, 7.—Baron Cuvier, in his celebrated work, "*Recherches sur les Ossemens Fossiles,*" has given an elaborate description of the remains of two kinds of slender-nosed Crocodilians, from the Kimmeridge clay of Honfleur, and the Oxford clay of Havre.

The specimens consist of the jaws, with teeth, vertebræ, and some bones of the extremities.† In one species, the vertebræ are biconcave; in the other, they are convexo-concave, and present a remarkable deviation from the recent lacertian type, namely, that they are placed in a reversed position,—the convex face of the vertebræ being directed anteriorly, or towards the cranium, and the concavity posteriorly; the name of the genus, *Streptospondylus* (reversed-spine) denotes this peculiarity of structure. The bodies of three or four large convexo-concave cervical vertebræ, were discovered in the Tilgate strata many years since, and are described in my various works (*Geol. S. E.* p. 300.); but no suspicion was entertained of their belonging to this genus, although I had repeatedly compared them with the figures of the Honfleur crocodile.‡ Pro-

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* Oss. Foss. Tom. V. pl. 6.

† Ibid. p. 143, pl. 8, 9.

‡ Reduced figures of two of these vertebræ are given in *Lign.* 138, figs. 5 and 7, p. 697.

fessor Owen, with his wonted penetration, first detected the true character of the Wealden vertebræ, in a large cervical, six inches long (now in the British Museum), in which two oblique processes are preserved on the concave end of the bone; their flat, oblong, articular faces, are directed downwards and outwards,—a character which at once proves them to be the posterior pair, for the anterior oblique processes would be directed upwards and inwards.* Vertebræ of the same species occur in the Isle of Wight; and of another species at Chipping Norton, and in the Lias of Whitby.

A concavo-convex caudal vertebra, with the relations of which I am unacquainted, was found in the same quarry in Tilgate Forest; a reduced outline of this unique fossil is given in *Lign.* 138, fig. 1. The centrum is of a subcylindrical form, and the articular face in front is concave, and that behind, convex; with a chevron-bone that is anchylosed to the body of the vertebra, and terminates in an inferior spine (*f.*); the pair of anterior oblique processes remains; the spinous process is destroyed.

CETIOSAURUS. From a considerable number of vertebræ and bones of the extremities of some gigantic aquatic reptiles, discovered in the Oolite in various places in Oxfordshire, Northamptonshire, and Yorkshire, Professor Owen established the present genus; the name indicating the general

* Brit. Rep. 1841, p. 92.

resemblance of these extinct Saurians to the Cetaceans.* The vertebræ differ from those of the Iguanodon, which they somewhat resemble, but far surpass in magnitude, in having their articular faces of a sub-circular form, and the body relatively short; the anterior face is nearly flat, and the posterior concave, in the dorsal vertebræ; but in the caudal, both faces are concave, and have a well-defined elevated margin, which gives the body a deeply excavated character, easily recognisable. Vertebræ of this reptile occur in Tilgate Forest, and were among my earliest discoveries. (*Geol. S. E.* p. 282.)† Some specimens are eight inches in the transverse diameter of the articular face, and but four and a half inches in the antero-posterior length of the body.‡ The original animals are supposed to have been of aquatic, and probably of marine habits, on the evidence of the sub-biconcave structure of the vertebræ and of the coarse cancellous tissue of the long bones, which are destitute of a

* Proc. Geol. Soc. Vol. III. p. 457.

† There are, in the British Museum, four consecutive caudal vertebræ, in the most perfect state, with a chevron-bone detached. These bones were originally imbedded in a block of Tilgate-grit, and in a position so unfavourable for their development, as to render it necessary to break the stone, and extract the vertebræ piece-meal.

‡ The osteological characters of these remains, and the physiological relations of the original animals, are described in *Brit. Rep.* 1841, p. 94—102.

medullary cavity. They must have rivalled the modern whales in bulk, for some specimens indicate a length of forty or fifty feet; they are supposed to have had web-feet, and a broad vertical tail.*

The remains of another gigantic marine Saurian have been discovered in the Green Sand at Hythe, in Kent; they consist of the bones of the pelvis and hinder extremities; the long bones have no medullary cavities. The femur is solid, and must have been nearly four feet in length. Neither the vertebræ nor the teeth of this reptile are known; but Professor Owen refers, provisionally, the large, conical, longitudinally-grooved teeth, that occur in the Kentish Rag, at Maidstone, and other places, (and which he has named *Polyptychodon*), to the same animal.†

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* Brit. Rep. p. 102.

† *Geol. Proc.* Vol. III. p. 449. The bones from Hythe have been presented by their discoverer, H. B. Makeson, Esq., to the British Museum. Teeth of the Polyptychodon are figured in Odontography, pl. 72.

# CHAPTER XVIII.

## FOSSIL REPTILES; COMPRISING THE DINOSAURIANS, PTERODACTYLES, TURTLES, SERPENTS, AND BATRACHIANS.

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III. DINOSAURIANS. — The term DINOSAURIA (*fearfully-great lizards*), is employed by Professor Owen, to designate the order of extinct colossal reptiles, comprising the *Megalosaurus*, *Hylæosaurus*, and *Iguanodon*, which, in their organization, establish the transition from the Crocodilians to the Lacertians;* and whose essential osteological characters are thus tersely expressed: —

"This group, which includes at least three well-established genera of Saurians, is characterised by a large *sacrum*, composed of five anchylosed vertebræ of unusual construction; by the height, breadth, and outward sculpture of the neural arch of the dorsal vertebræ; by the two-fold articulation of the ribs to the vertebræ, viz. at the anterior part of the spine by a head and tubercle, and along the rest of the trunk by a tubercle attached to the transverse process only: by broad, and sometimes complicated, coracoids, and long and slender clavicles; whereby Crocodilian characters of the

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* Brit. Rep. 1841, p. 144.

"vertebral column are combined with a Lacertian type of the pectoral arch. The dental organs also exhibit the same transitional or connecting characters, in a greater or lesser degree. The bones of the extremities are of large proportional size for Saurians; they have large medullary cavities, and with well developed and unusual processes, and are terminated by metacarpal, metatarsal, and phalangeal bones, which, with the exception of the ungueal phalanges, more or less resemble those of the heavy pachydermal mammalia; and attest, with the hollow long-bones, the terrestrial habits of the species.

"The combinations of such characters,—some, as the sacral ones, altogether peculiar among Reptiles,—others borrowed, as it were, from groups now distinct from each other—and all manifested by creatures far surpassing in size the largest of existing reptiles, will, it is presumed, be deemed sufficient ground for establishing a distinct tribe, or sub-order, of Saurian Reptiles.

"Of this tribe, the principal and best established genera are the *Megalosaurus*, the *Hylæosaurus*, and the *Iguanodon*; the gigantic *Crocodile-lizards* of the dry land: whose peculiarities of osteological structure distinguish them as clearly from the living terrestrial and amphibious Saurians, as the opposite modifications for an aquatic life, characterise the extinct Enaliosaurians, or marine lizards."*

The elaborate investigation of the fossil remains of these stupendous beings, and the luminous exposition of their organization and physiological relations, embodied in the report to which the above extract is introductory, must be regarded as among the most important contributions to Palæontology; and afford a striking example of the successful application

* Brit. Assoc. Rep. 1841, p. 103.

of profound anatomical knowledge to the elucidation of the most marvellous epoch in the earth's physical history,—the *Age of Reptiles.*

From the great size of the bones of these reptiles, their remains have excited the curiosity even of the common observer; and although an exaggerated idea has been generally entertained of the magnitude of the original animals, yet even when reduced to their natural proportions by the rigorous formula of the anatomist, applied to the accumulated relics which years of laborious research have exhumed from their rocky sepulchres, and deposited in our museums, their dimensions are sufficiently stupendous to satisfy the most enthusiastic lover of the marvellous.*

Let the reader visit the British Museum, and after examining the largest thigh-bone of the Iguanodon, repair to the zoological gallery, and inspect the recent Crocodilian reptiles, some twenty-five or thirty feet in length; and observe that the fossil bone equals, if not surpasses, in size the entire thigh of the largest of existing reptiles; then let him imagine this bone clothed with proportionate muscles and integuments, and reflect upon the enormous trunk

* The comparative anatomist may now enjoy the privilege of inspecting, at his ease, the immense collection of fossil reptiles in the British and other Museums, and with all the advantages which access to the first anatomical collection in the world, the Hunterian Museum, presents for the comparison of fossil with recent structures.

which such limbs must have been destined to move and to sustain—and he will obtain a just notion of the appalling magnitude of the lizards which inhabited the Country of the Iguanodon.

The general characters of the extinct reptiles comprised in the order *Dinosauria*, must be known to the intelligent reader, from the various popular notices which have from time to time appeared; and their names have become as familiar as household words. As Professor Owen's Report embodies all that is at present known of their osteology, and an able abstract of this memoir appears in the Penny Cyclopædia (*Art. Saurians*), I restrict myself to a few general remarks on the form and structure of the teeth, bones of the extremities, &c.

MEGALOSAURUS (*gigantic saurian, or lizard*). *Bd.* pl. 23.—The oolitic limestone of Stonesfield, in Oxfordshire, has long been celebrated for the bones and teeth of a gigantic reptile, which Dr. Buckland first described by the name of *Megalosaurus*, in a highly-interesting memoir (*Geol. Trans.* Vol. I. *second series*), illustrated by figures of the teeth of a portion of the lower jaw, the sacrum, femur, and other bones. The remains of this reptile are also frequently discovered in the Wealden (see *Foss. Til. For.* p. 67, pl. 19.). The most important relic of this great carnivorous terrestrial lizard is a portion of the right ramus of the lower jaw, containing one perfect tooth, and the germs of several teeth (*Bd.* pl. 23, figs. 1, 2.). The tooth of the

Megalosaurus (Pl. VI. fig. 7.), has a conical, laterally compressed crown, with the point recurved like a sabre, and the edges trenchant and finely serrated. The implantation of the teeth is very peculiar, and exhibits the dentition of the Crocodilians blended with that of the Lacertians. The jaw has an outer parapet (see *Bd.* pl. 23.), as in the true lizards (see *Lign.* 137.), but the teeth are fixed in distinct sockets, formed by transverse partitions, that are attached to a mesial (*inner*) parapet, composed of a series of triangular osseous plates; the bases of the old teeth, and the germs of the new ones, being thus enclosed and concealed. The tooth is formed of a central body of dentine, the crown having a coating of enamel; and the whole an external investment of cement, which forms a thicker layer around the fang; the pulp-cavity is occupied by coarse bone, in the adult tooth. The microscopical examination shows the dentine to consist of very fine calcigerous tubes, $\frac{1}{28,000}$th of an inch in diameter, without any admixture of medullary canals, radiating from the pulp-cavity at right angles with the external surface of the tooth, and sending off numerous secondary branches; these ultimately dilate into, or inosculate with, a stratum of calcigerous cells that separates the dentine from the enamel.* A thin slice of a vertical section, viewed by trans-

* Odontography, p. 271, which should be consulted for more minute details.

mitted light, is represented Pl. VI. fig. 7; showing the calcigerous tubes radiating from the centre, and terminating in the stratum of cells; this cellular structure is invested with a layer of enamel, and the latter with an external coat of cement, indicated by the dark outline.*

Three specimens of the sacrum, composed of five anchylosed vertebræ (*Foss. Til. For.* pl. 19. fig. 12.) have been discovered; one of these is from Tilgate Forest. It has already been mentioned, that to the sagacity of Professor Owen we owe the interpretation of this remarkable feature in the osteological structure of the Dinosaurians.†

This colossal carnivorous saurian, whose length is estimated at thirty feet,‡ appears to have been terrestrial, and an inhabitant of the same *terra incognita* as the Iguanodon: it probably preyed on the smaller reptiles, and the young of the Iguanodon, Crocodilians, &c.

HYLÆOSAURUS (*Wealden lizard*) OWENII.§ (G.A.M.) *Wond.* Pl. IV. (*Geol. S. E.* pl. 5.).—In the

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* To fully comprehend the minute structure of these and the other teeth figured in Pl. VI. Professor Owen's plates should be examined: the small scale necessarily adopted in the present work, rendering it impossible to do justice to the subject.

† Brit. Rep. 1841, p. 105.

‡ Oper. cit. p. 110.

§ Instead of the inappropriate term *armatus*, applied to this reptile as a specific designation, in compliance with a suggestion in the first description of this most interesting of my summer of 1832, I obtained the interesting specimen which first demonstrated the existence of the remains of another extraordinary modification of Saurian organization in the Wealden. The circumstances which led to this discovery, afford an instructive lesson to the young collector.

Upon visiting a quarry in Tilgate Forest, which had yielded many organic remains, I perceived in some fragments of a large mass of stone, which had recently been broken up and thrown on the road-side, traces of numerous pieces of bone. I therefore collected all the recognisable portions of the block, and had them conveyed to my residence. The first step was to cement together those pieces that would admit of juxtaposition, and these were at length united into a block of stone five feet long, three wide, and about one foot thick. This was firmly fixed in a stout frame, to prevent the separation of the united portions during the process of chiselling. Guided by the indications which the sections visible on the edge afforded, a thin iron wedge was carefully driven in, about half an inch above the uppermost layer of bones, and a large slab was flaked off; the three dermal spines (*Wond.* Pl. IV. fig. 5.) in the middle of the specimen were thus exposed, and shivered to pieces; some fragments adhered to the mass broken off, others to the block, and many were detached; every piece, however small, was collected, and those adhering to the slab were chiselled out; and the whole were then carefully replaced and cemented to the bones that remained imbedded in the large block. After an interval of some days, to allow of the firm cohesion of the cemented parts, the task was

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discoveries in the Wealden, I would distinguish the *Hylæosaurus*, by the name of the eminent philosopher to whose genius and indefatigable labours British Palæontology is so deeply indebted.

resumed, and the stone chiselled away, till some portion of the large bones of the pectoral arch (*Wond.* Pl. IV. fig. 7.) were observed. The specimen was at length brought to the state in which it now appears (in the British Museum): but during the progress of its development, which occupied many weeks, it was repeatedly necessary to suspend the work, and unite displaced fragments of bone, and resume the task after their consolidation. The plate in the *Geol. S. E.* conveys a good idea of the original.

The specimen consists of a part of the spinal column, composed of seven dorsal and three or four cervical vertebræ, almost in their natural juxtaposition, with obscure indications of a part of the base of the skull; eleven ribs; the bones of the pectoral arch (two *coracoids* and *scapulæ*); with numerous dermal bones and spines. A second specimen of this reptile was found near Bolney, in Sussex; and like the former, it was, unfortunately, almost wholly destroyed by the labourers; but I obtained many bones, some of which are perfect, and indicate an animal of considerable magnitude: a *scapula*, nineteen inches long, an arm-bone or *humerus*, numerous ribs, bones of the phalanges, &c. A fine series of twenty-six caudal vertebræ, having a total length of nearly six feet, with chevron bones and dermal spines, was discovered in 1837, in Tilgate Forest. A few detached bones are the only other relics of this reptile that have come under my observation.*

* See "Memoir on the Remains of the Iguanodon, Hylæosaurus, and other Saurian Reptiles," by the Author. *Philosophical Transactions* for 1841, Part II.

The osteological characters presented by these remains afford another example of the blending of the Crocodilian with the Lacertian type of structure; for we have in the pectoral arch the scapula or omoplate of a crocodile associated with the coracoid of a lizard. Another remarkable feature in these fossils is the presence of the large angular bones or spines (described p. 704, figured *Lign.* 140.), which, there is reason to infer, constituted a serrated crest along the middle of the back; and the numerous small oval dermal bones, which appear to have been arranged in longitudinal series along each side of the dorsal fringe.*

The vertebræ, ribs, and other parts of the skeleton found in these specimens, also present modifications of structure of great interest.† No specimens of teeth have been found associated with the remains of the Hylæosaurus, in such manner as to afford unequivocal proof of their belonging to that animal. But in the same quarries, teeth, decidedly of the Lacertian structure, are occasionally found, and may probably be referred to that reptile. These teeth (see Pl. VI. fig. 6, [a].) are about 1¼ inch in length, and commence at the base with a cylindrical shank, which gradually enlarges into a crown of an obtuse lanceolate form, convex in front,

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* Geol. S. E. p. 323.

† See Brit. Rep. 1841, pp. 111—120. Phil. Trans. 1841, pp. 141—144, Pl. X.).

depressed behind, and terminating in an angular rounded apex, the margins of which are generally more or less worn, as if from detrition. The crown is solid, but the fang encloses a simple, small, pulp-cavity; the surface is enamelled, and covered with very fine longitudinal striæ; the base in every specimen appears broken transversely, as if it had been anchylosed to the jaw, or to the base of a socket. The fang never presents an appearance of lateral adhesion, as if belonging to a Pleurodont lizard. Sections of these teeth expose a simple, central, medullary canal, the upper part of which is generally filled with the ossified remains of the pulp; and this is surrounded by a body of firm dentine, with extremely minute calcigerous tubes radiating from the centre to the periphery of the tooth, which is invested with a relatively thick coat of enamel, in which no structure is apparent. Pl. VI. fig. $6^b$, represents a small portion of a vertical slice, highly magnified and viewed by transmitted light. The reference of these dental organs to the Hylæosaurus must not, however, be considered as conclusive, until confirmed by the discovery of the teeth attached to the jaw, in connexion with other parts of the skeleton.* The locomotive organs of the Hylæosaurus are but imperfectly known; a perfect humerus, one phalangeal bone, and

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* Brit. Rep. 1841, p. 118. Phil. Trans. 1841, p. 144, Pl. VI. figs. 9, 10, 11.

fragments of the fibula (the small bone of the leg), are the only bones hitherto observed. The length of this reptile may probably be estimated at from twenty to thirty feet.

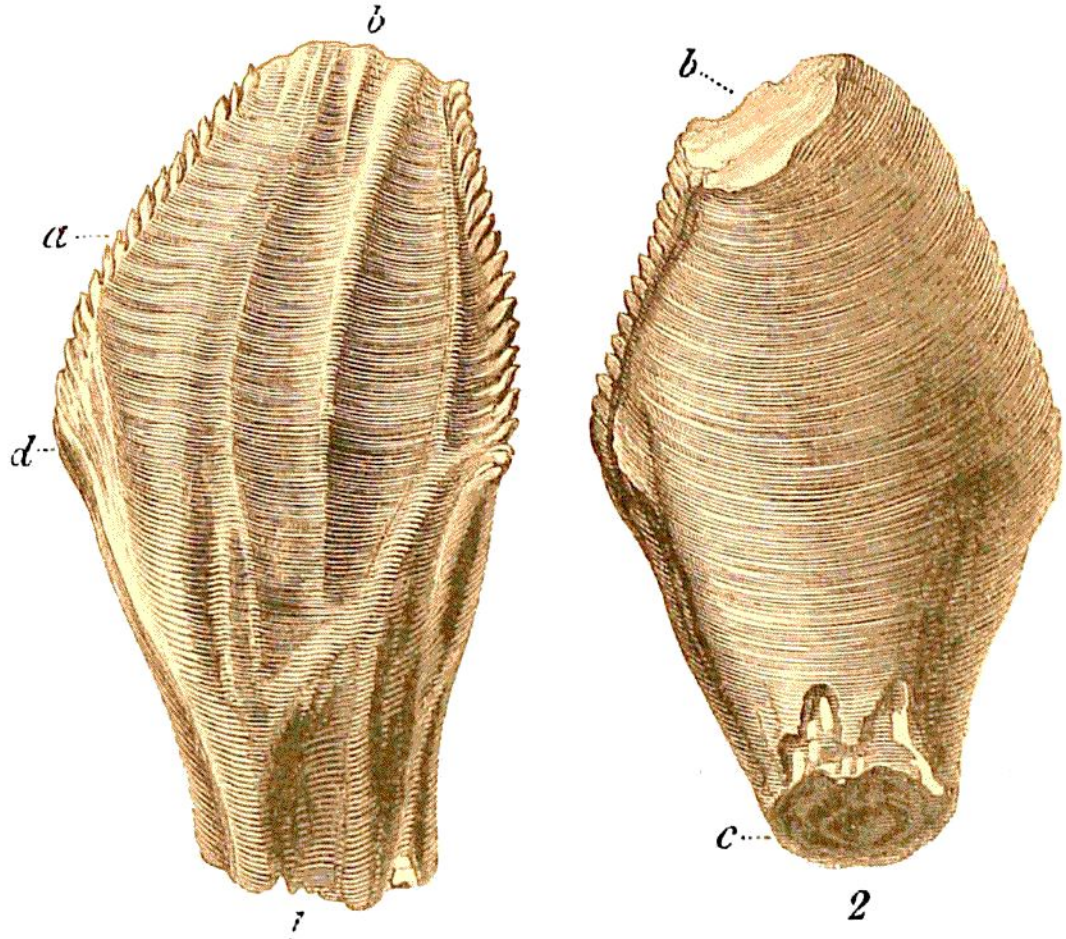
IGUANODON. (G. A. M.) *Wond.* Pl. II. III.—Soon after my first discovery of the remains of vertebrated animals in the strata of Tilgate Forest, some teeth of a very remarkable character particularly engaged my attention, from their dissimilarity to any that had previously come under my notice; even the quarrymen, who had been accustomed to collect the teeth of fishes and other relics, had not observed any specimens of this kind until shown those which I had extracted from a block of conglomerate picked up by the road-side.* Attention having thus been directed to those interesting fossils, examples were soon discovered of teeth in various conditions, from the sharp, unused tooth of the young reptile, to the obtuse, worn-out crown of the adult. From the resemblance of the perfect teeth to those of the Iguana, a land lizard of the West Indies, I proposed the name of *Iguanodon* (signifying an animal with teeth like those of the Iguana), for the extinct reptile to which they be-

* These are described in *Foss. South D.* (published in 1822), p. 54, under the head "*Teeth and bones of unknown animals.*" This was the earliest published notice of the fossils of the Wealden; it contains also a description of a tooth of the Megalosaurus (p. 55, No. 42.).

longed; a name sanctioned by the illustrious Cuvier, and now familiar to most of my readers. The numerous bones and teeth subsequently exhumed from the strata of Tilgate Forest, and other localities in the Wealden of Sussex, and of the Isle of Wight; and the considerable portion of the skeleton of an individual discovered by Mr. Bensted, in the Kentish Rag, have supplied the data upon which our present knowledge of the characters of the original is based. Unfortunately, the form and structure of the cranium are unknown; and of the jaw, a fragment with merely the fangs of teeth, is the sole known relic. I regret that the limits of the present volumes will only admit of reference to the various works containing notices of the remains of the Iguanodon.

In *Wond.* p. 389—401, a brief account will be found of the character of the teeth (p. 390), of the femur, caudal vertebræ, horn, ungueal bones, &c. (Pl. III.); and of the Maidstone specimen (Pl. II.).

The "Geology of the South-east of England" contains accurate figures of the long bones of the leg (*Geol. S. E.* pl. 2.), femur, clavicles (*Geol. S. E.* pl. 4.), tympanic bone (*Geol. S. E.* pl. 2.), horn and ungueal bone (*Geol. S. E.* pl. 3.). In the "Fossils of Tilgate Forest," there are fifteen quarto plates devoted to the illustration of the bones and teeth of the Iguanodon, and other Wealden reptiles. The osteological structure is fully detailed in *Brit. Rep.* 1841, pp. 120—144. A general notice of




LIGN. 142. TOOTH OF THE IGUANODON: *nat.* *Tilgate Forest.*

Fig. 1.—Front aspect, showing the longitudinal ridges, and denticulated margins of the crown of the tooth.

2.—View of the back, or inner surface of the tooth,

*a*. The denticulated margin.

*b*. The apex of the crown, worn by use; *b*. fig. 2, shows the oblique smooth surface produced by mastication.

*c*. A transverse fracture of the fang, showing a section of the medullary cavity occupied by the ossified remains of the pulp.

*d*. Marks the inferior limit of the denticulated margin; if a line were carried horizontally from *d*, across the tooth, the under figure would represent a tooth worn down below the denticulations, and deprived of its peculiar dental characters; in this state the tooth somewhat resembles an incisor of a Rhinoceros.

the principal bones of the Iguanodon, with plates, will be found in *Phil. Trans.* 1841, pp. 131—151; and all the most interesting specimens have been admirably arranged, and are now displayed in the gallery of Palæontology of the British Museum, by its distinguished curator, C. König, Esq.

TEETH OF THE IGUANODON. *Lign.* 142.—Although the works referred to contain descriptions and accurate figures of the teeth in various stages of development and of detrition, from the young perfect tooth, with a pointed acute angular crown, to the mere stump worn flat by use, and with its fang, destroyed by absorption from the pressure of the successional tooth; a few additional remarks may be interesting to the student. The beautiful lignograph (*Lign.* 142, by *Mr. James Lee*) of a very large tooth, found imbedded in the trunk of a Clathraria, as if it had snapped off while the animal was in the act of gnawing the tough stem, is introduced as an example of the configuration of the crown of a perfect, fully developed tooth.* The root of the fang is broken off; but in teeth of this kind it generally tapers to a point, indicating the probability that the teeth were implanted in sockets, and not simply imbedded in the walls of a parapet, as in the recent Iguana. The point of the tooth is partly worn away, and fig. 2, *b*, shows the oblique

* For a description of the development of the teeth of the Iguanodon, see Foss. Til. For. p. 72.

surface produced by this cause (as explained in *Foss. Til. For.* p. 73.). The denticulated margins are well developed; in the present sketch, fig. 1, they appear as simple serrations; but viewed laterally, they are seen to be formed by a series of denticulated plates (*Wond.* p. 391, fig. 6.). The crown of a tooth of a young animal, worn at the summit, and presenting but three longitudinal ridges in front, is represented Pl. VI. fig. 4[a].* The microscopical structure, as first demonstrated by Professor Owen,† consists of a simple pulp-cavity in the centre of a body of dentine permeated by calcigerous tubes, but with this peculiar modification, that the dentine is traversed by medullary canals, radiating at definite intervals from the pulp-cavity nearly to the periphery of the tooth, and running parallel with the calcigerous tubes; thus constituting a softer and coarser dentine than in the other reptiles, and resembling that which characterises the teeth of the Sloth and Megatherium (*Odontography*, pl. 71.). The crown of the tooth is covered with a layer of enamel, which is thickest on the external surface; and the fang is invested with cement. The structure here described is

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* Pl. 4, and 17, "*Fossils of Tilgate Forest*," contain representations of upwards of thirty specimens of teeth in various states of development and detrition, and probably belonging to different parts of the jaw.

† Odontography, p. 249.

shown in Pl. VI.; fig. 4*b*, a vertical, and fig. 4*c*, a transverse section of a tooth, seen by transmitted light, with a high magnifying power. The calcigerous tubes, according to Professor Owen, are $\frac{1}{25,000}$th of an inch in diameter. Sections of the teeth of the Iguanodon are beautiful objects under the microscope, for the medullary canals are generally of a deep yellowish brown colour.

The internal structure of the teeth of the Iguanodon is thus in perfect accordance with their external configuration, and must have been admirably adapted, in every stage, for the laceration and comminution of the tough vegetable substances, which, there is every reason to conclude, constituted the food of this colossal oviparous quadruped.

JAW OF THE IGUANODON.—A portion of the right ramus of a lower jaw of a reptile, probably of an Iguanodon, has been discovered in a block of sandstone from Tilgate Forest. It consists of a fragment, six inches long, of the dentary bone, with a small portion of the opercular; and contains the fangs of fifteen teeth, which are closely and evenly set in a regular series, and imbedded laterally in grooves, or sockets, in the dentary bone; there are three or four sockets of successional teeth on the inner side of the base of the old teeth (*Phil. Trans.* 1841, Pl. V. figs. 1, 2.). Unfortunately, all the crowns of the teeth are wanting; and we are, therefore, deprived of the only certain proof of identity. In my memoir on this fossil in the *Phil. Trans.*

(1841, p. 131), the characters which appear to establish its claims to the Iguanodon are minutely described; and, at the same time, the imperfect nature of the evidence is candidly admitted.*

The outer parapet of the dentary piece is entire, and its upper margin is finely crenated. All the fangs of the teeth are exposed, but there are traces of a thin inner wall, indicating, as Professor Owen suggests, the probability that, as in the Megalosaurus, the teeth were supported mesially by an osseous plate, and were implanted in distinct sockets.†

VERTEBRÆ OF THE IGUANODON, *Lign.* 138, p. 697.—The remains of the vertebral column of the Iguanodon, consisting generally of broken and water-worn dorsal and caudal vertebræ, deprived of their processes, and reduced to the state of the specimens represented *Lign.* 138, fig. 6, are so abundant in

* Professor Owen, whose opinions on every question connected with Zoology and Palæontology are entitled to the greatest deference, is disposed to prefer the claims of the Hylæosaurus to this unique relic; but after a careful perusal of his able exposition of its osteological structure, I consider this conjecture less probable than that which refers the jaw to the Iguanodon: in the language of the illustrious Cuvier,—"*le temps confirmera ou infirmera cette idée.*" The student should consult Brit. Rep. p. 119.

† The collector will perceive the importance that attaches to the discovery of even a fragment of the jaw of an unknown reptile, containing teeth in their natural position.

some of the Wealden strata, that a short account of their characters may be useful. A reference to *Lign.* 138, and its description, will render the following remarks intelligible to the general reader. The vertebræ of the Iguanodon are distinguishable from those of other reptiles which occur in the same strata, by the following peculiarities, which the figure of a perfect specimen of a caudal vertebra (*Lign.* 138, fig. 3.), will serve to illustrate. The body, or centrum, is either flat or somewhat depressed on both articular faces; its sides are nearly flat, or convex vertically (as in fig. 3.), and slightly concave lengthwise, or from front to back: in some examples, the body is more contracted towards the inferior surface, as in fig. 6; and in the vertebræ, near the middle of the tail, the sides are compressed, so as to give an angular contour, and somewhat vertical elongation to the face, as in fig. 4; but in the dorsal vertebræ, the articular faces are nearly circular, but somewhat higher than wide. In the caudal vertebræ, the inferior angles of the body are truncated (*w*, figs. 3, 4.), and present an oblique, smooth face, to articulate with the chevron-bone (*f*, fig. 3.). The annular part is united to the body by suture (*o*, fig. 3.), and anchylosed in the dorsal vertebræ; and in these bones the neural arch is very high, and greatly expanded, and its bases extend transversely inwards, and join each other below the spinal canal, forming a ring, or bony channel, to contain the spinal chord. "The transverse processes are straight, and very long in the vertebræ from the middle of the trunk, indicating a considerable expanse of the abdominal cavity, adapted for the lodgment of the capacious viscera of a herbivorous quadruped."* The spinous processes are large, and of great height (*d*, fig. 3, see also, *Wond.* Pl. III. fig. 8.), in the anterior caudal vertebræ; and in these bones the chevrons, or hæmapophyses (*f*, fig. 3, fig. 2.), are also of considerable length; the bases of the latter are always united (*g*, fig. 2.), and often blended, so as to form but one face for articulation with the truncated inferior angles of the body of the vertebræ, leaving an elongated vertical channel for the passage of the large blood-vessels of the tail.† The external surface of the vertebræ of the Iguanodon is more or less marked with fine longitudinal striæ; a character by which, Professor Owen states, even fragments may be distinguished from those of the Megalosaurus, for the latter have always a smooth and polished surface.

BONES OF THE EXTREMITIES.—The thigh-bone, both bones of the leg (*tibia* and *fibula*), and many of the metatarsal and phalangeal bones, have been discovered; the osteology of the hinder extremity

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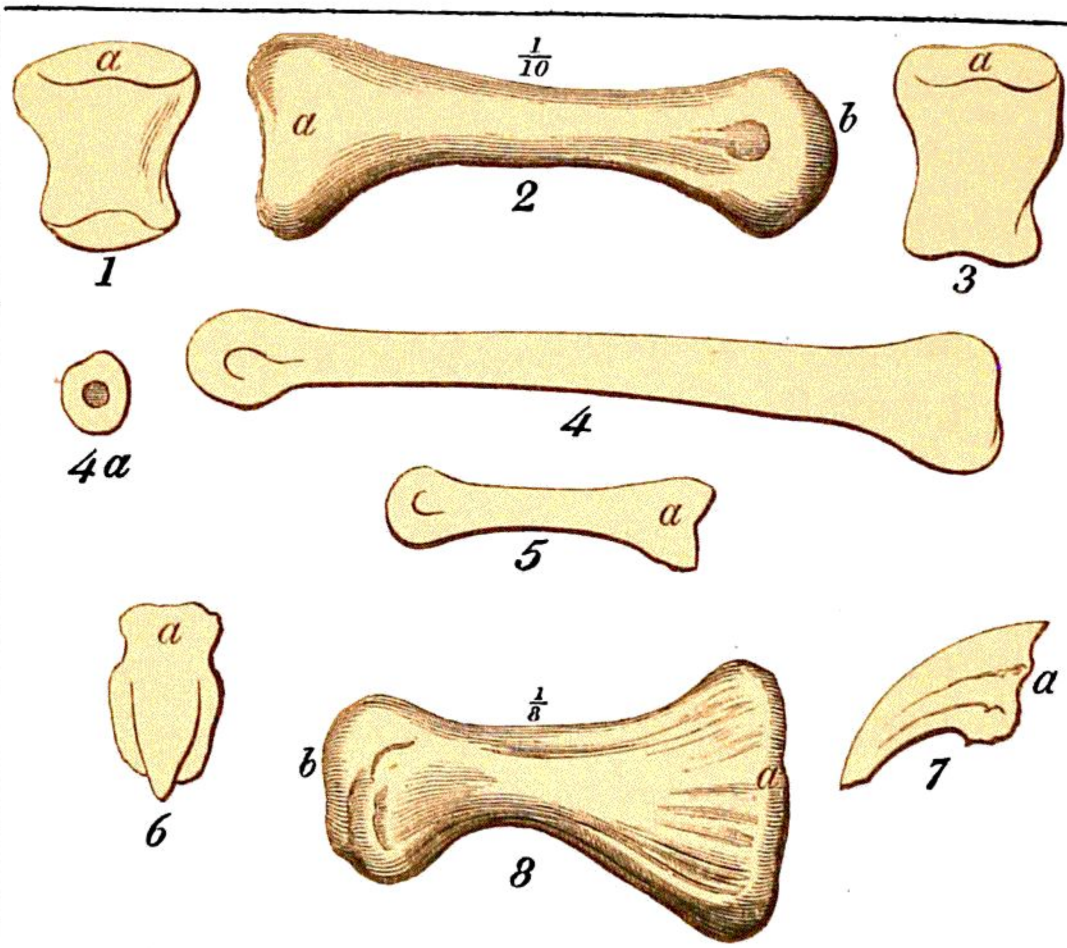
* Brit. Rep. p. 125. The essential characters pointed out in the text, were first demonstrated by Professor Owen.

† An elaborate investigation of the vertebræ of the Iguanodon is given, Brit. Rep. p. 125—133.

is, therefore, almost perfect: but no *certain* example of the bones of the arm (*humerus*), or fore-arm (*radius*, and *ulna*), are known. The thigh-bone is of a very remarkable character, having a closer resemblance to the femur of a huge mammalian, than to that of a reptile. Several perfect specimens have been discovered, and with the corresponding bones of the leg; but the first fragment that came under my notice, was the middle portion of the shaft of a femur of enormous size, and of an irregular quadrangular form; and so shapeless and unintelligible, that several years elapsed before its real nature was determined.*

An entire thigh-bone of an adult Iguanodon, from the Weald clay in the west of Sussex, is three feet eight inches in length, and thirty-five in circumference at the condyles; and I have a femur of a very young animal, that is but five inches long. The form of the thigh-bone is so peculiar, that fragments may easily be recognised. The head of the femur is hemispherical, and projects inwards; a flattened trochanter, or process, forms (see *Wond.* Pl. III. fig. 11, *a.*), the external boundary of the neck

* It is figured, Foss. Til. For. pl. 18. The palæontologist who now sees the perfect bones in the British Museum, and interprets their characters and relations by the aids which the present advanced state of science places at his command, can but little appreciate the difficulties which beset the earlier collectors in their attempts to develope the mutilated relics of unknown types of organization.




LIGN. 143. BONES OF THE FEET AND CLAWS OF THE IGUANODON.
*Wealden. Tilgate Forest.*
(*See Wond. Plate II.*)

Fig. 1.—Metatarsal: original 6 inches long: upper surface.
2.—Metacarpal bone.
3.—Under surface of fig. 1.
4.—A phalangeal bone of the fore-foot, the original 14 inches long.
4a.—A transverse section of the same, showing the medullary cavity.
5.—One of the second row of phalangeal bones of the fore-foot.
6.—View from above of one of the claw-bones of the hind-foot: $\frac{1}{6}$ *nat.*
7.—Profile of claw-bone of fore-foot: $\frac{1}{6}$ *nat.*
8.—Metatarsal, or bone of the hind-foot: $\frac{1}{8}$ *nat.*
*a.* Denotes the *proximal* articulation, or that nearest the trunk.
*b.* The *distal*, or extremity most distant from the trunk.

of the bone, from which it is separated by a deep and narrow vertical fissure; the shaft is of a subquadrangular shape, and, a slightly elevated ridge, produced by the union of two broad, flat, longitudinal surfaces, extends down the middle of the anterior face, and, diverging towards the inner condyle, gradually disappears. The bone terminates below in two large condyles, separated in front and behind by a deep, narrow cleft, or groove (*Wond.* Pl. III. *d.*). Near the middle of the inner edge of the shaft (*Wond.* Pl. III. *b.*), there is a compressed ridge, with an angular projection, or trochanter. Thus the upper part of the femur may be known by the presence of the flattened, or laterally compressed trochanter; and if that process be wanting, a fractured surface, indicating its position, may be detected; the middle of the shaft is characterized by its broad angular faces, and the inner submedian trochanter: the condyloid, or inferior extremity of the bone, may be distinguished by the deep groove between the condyles, both in front and behind.

BONES OF THE FEET, *Lign.* 143.—As separate bones of the feet of the Iguanodon, for example, *metacarpals*, *metatarsals*, *phalangeals*, and *ungueals*, often occur in the strata of the Wealden, figures of several specimens, on a reduced scale, are introduced, *Lign.* 143; and may enable the student to identify those he may meet with in his researches.*

* See Brit. Rep. 1841, p. 137—142.

The ungueal phalanges, or claw-bones, which were invested with the nail, are sometimes found of an enormous size; from a quarry near Horsham, Mr. Holmes obtained specimens more than five inches long, and three inches wide at the articular extremity.

Although much remains to be known of the osteology of the Iguanodon, it is manifest, from the data hitherto obtained, that the original was a terrestrial oviparous quadruped, of gigantic proportions; combining with its reptilian organization, the massy, cumbrous limbs of the existing herbivorous pachydermata, or rather approximating to the Dinotherium, Megatheriun, and other extinct colossal mammalia. The probable size of the animal to which the largest bones in our collections belonged, is estimated by Professor Owen as follow:* length of the head, 3 feet—of the trunk, 12 feet—of the tail, 13,—*total length*, 28 *feet*. According to this calculation, the Iguanodon was surpassed in length by the Megalosaurus.

This statement will surprise the reader who, from the popular notions of the size of the Iguanodon, has entertained the idea that this reptile attained seventy feet in length; but the discrepancy between the estimate of Professor Owen, and that suggested in my former works, admits of an easy explanation.

In my earliest notices of the Iguanodon, which

* Brit. Rep. 1841, p. 144.

were published from time to time, as fresh discoveries disclosed new modifications of structure in this prodigious creature, an attempt was made to estimate the probable magnitude of the original, by instituting a comparison between the fossil bones and those of the Iguana; the recent type which the form of the teeth seemed to point out as the one most nearly related to the extinct reptile. It was thus shown that if the proportions were the same in both, the Iguanodon must have attained seventy feet or more in length. But this statement was qualified (more than *eleven years since*) by the following remarks:—"It is not, of course, pretended that such an estimate can offer more than *a very distant approximation to the truth;* yet it may be confidently affirmed that a reptile, which required a thigh-bone larger than that of the Elephant to support it, could not be of less colossal dimensions. Should subsequent discoveries prove that the Iguanodon more nearly corresponded in the proportions of the tail with the Crocodilian family than with the Lizards, its total length would be much less than is here inferred; and from the shape of some of the fossil metacarpal and phalangeal bones, it appears highly probable that the original *was more bulky in proportion to its length*, than the existing Lacertians." (*Geol. S. E.* p. 315.). In subsequent notices of the Iguanodon this opinion was reiterated, and on the discovery of perfect caudal vertebræ, I expressed my conviction that the tail of the Iguanodon must have been much shorter than in the Iguana, and that, instead of being round and prehensile, it was compressed laterally, and largely developed in a vertical direction. In my last Memoir, in the *Phil. Trans.* 1841, pp. 137—140, it is stated that "from the shortness of the caudal vertebræ, and the length of the spinous processes of the neura and hæmapophyses, indicating a great vertical development of the tail, it is probable that this organ was not long and slender as in the Iguana, but that it approximated more nearly to the tail of the *Doryphorus.*"

The length of the united head and trunk, according to my estimate (*Geol. S. E.* p. 316.), is seventeen feet and a half; by Professor Owen's it is reduced to fifteen feet; a difference of no importance in such merely approximative calculations, particularly when the form of the cranium is unknown. The only discrepancy is in the estimated length of the tail; if the Iguanodon resembled the Iguana in its caudal proportions, its total length might be seventy feet; but if, as above stated, the tail was short, laterally compressed, and developed in a vertical direction, the total length of the animal would be proportionately reduced, and the most gigantic individuals may not have far exceeded thirty feet in length.

IV. Lacertian Reptiles.—The recent Lacertians, or true Lizards, are smaller and less highly organized reptiles than the Saurians of the Crocodilian order; and their dermal covering consists of a finer and more delicate squamous integument. They are also characterised by important modification in their osteological structure. The spinal column is almost always composed of concavo-convex vertebræ, with the convexity behind; the ribs are slender and rounded, having a single convex tubercle of attachment. The fossil species are, for the most part, of gigantic dimensions, and deviate in a striking manner from any that now exist. Vertebræ of the recent lacertian type are very rare in the secondary strata; I believe a few in my cabinet, obtained from the sandstone of Tilgate Forest, and which must have belonged to a very small unknown reptile, are the most ancient examples at present known.

MOSASAURUS. *Wond.* p. 299.—The fossil lizard of Maestricht, named *Mosasaurus* (lizard of the Meuse), from the river adjacent to the quarries of St. Peter's Mountain, in which its remains have been discovered, is briefly described, *Wond.* pp. 297—301. A specimen, with the jaws, and bones of the palate armed with teeth, now in the museum at Paris, has long been celebrated; and is still the most precious relic of this extinct reptile hitherto discovered; a small, but faithful representation is given *Bd.* pl. 20, and *Wond.* p. 299. The specimen is four and a half feet long, and two and a half feet wide; it consists of both sides of the lower jaw, with the right ramus of the upper jaw in its natural position, and the left, which is displaced, lying across the articular extremity of the left branch of the lower jaw: of the *pterygoid* bones, which are armed with teeth; and of the left *tympanic* bone, which is but little removed from its natural situation, and connects the lower jaw with the cranium.*

The teeth are large, and supported on expanded conical osseous eminences, which are anchylosed to the alveolar ridge of the jaw. The crown of the tooth is conical, recurved, with the outer face nearly flat, and this space is bordered on each side by a longitudinal ridge; giving the tooth somewhat of a pyramidal figure. Professor Owen states that the crown consists of a body of simple and firm dentine, with fine and close-set calcigerous tubes, enclosing a simple pulp-cavity; irregular processes of the latter extend as medullary canals into the conical base of the tooth, but not, as in the Iguanodon, into the substance of the coronal dentine; the dentine is invested with a moderately thick coat of enamel.† The teeth of the Mosasaurus have not been found in

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* An admirable cast of this specimen, presented to me by the late Baron Cuvier, is preserved in the British Museum, in a case near the bones of the Iguanodon. On a late visit I was concerned to observe that the *tympanic bone* was absent; its presence in this model enabled me to ascertain the nature of the analogous bones of the Iguanodon. *Geol. S. E.* p. 306.

† See Odontography, p. 258, and pl. 72.

the English strata; but in the arenaceous deposits of the Chalk in the United States, Dr. Morton of Philadelphia has discovered teeth that appear to me to be identical with those of Maestricht.

The only probable relics of the Mosasaurus known in the British chalk, are four or five vertebræ from Sussex; one posterior dorsal (?), and two caudal, with their chevron bones (*Geol. S. E.* p. 146), which are anchylosed to the middle of the centrum. I have one anterior caudal vertebra, partially invested with flint, from Brighton.

The Mosasaurus was an aquatic reptile, about twenty-five feet long, holding an intermediate place between the Monitors and the Iguanas; it appears to have had webbed feet, and a tail of such construction, as to have served as a powerful oar, and enabled the animal to stem the waves of the ocean, of which Baron Cuvier supposed it to have been an inhabitant.*

LEIODON.†—Under this name (in allusion to the smoothness of the teeth) Professor Owen has described a splendid fossil, consisting of a portion of the lower jaw of an acrodont reptile, with teeth, discovered by Edward Charlesworth, Esq., in the

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* Several fine portions of the jaws, and many vertebræ of this animal, are in the British Museum. In a splendid work, "*Histoire Naturelle de la Montagne de St. Pierre*," by the late Faujas St. Fond (1 vol. folio, with numerous plates), there are admirable figures of the remains of the Mosasaurus.

† Brit. Rep. p. 144. Odontography, p. 261, and pl. 72.

Chalk of Norfolk (*Wond.* p. 339.). This specimen was submitted to my inspection, many years since, by Mr. Charlesworth, and I then pointed out its analogy to the jaw of the Mosasaurus, indicated by the mode in which the smooth, conical, pointed teeth are anchylosed to, and supported by, osseous bases; and the distinctive character which the trenchant margins and uniform convexity of the teeth presented; and, at the same time, suggested that a reptile so closely allied to the Mosasaurus might have possessed a vertebral column, composed of bones with no appreciable distinctive characters from those of the former; and as no teeth of the Mosasaurus had been found in the English Chalk, the vertebræ which I had ascribed (*Geol. S. E.* p. 46.) to the Maestricht reptile, might possibly belong to the Norfolk species. No solution of the problem has yet been afforded, for no other relics have been discovered. The teeth have a simple pulp-cavity, surrounded by fine dentine, with an external layer of enamel. Professor Owen alludes to the lamellar decomposition of the dentine (*Odontography*, p. 262.) exhibited by some of these teeth, and observes that, at the base of the crown of a fractured tooth, these lamellæ are shown to be concentrically arranged. Mr. Charlesworth has recently had a section made of a perfect tooth of the *Leiodon*, and the pulp-cavity was found filled with a solid cone of flint; the silex must, therefore, have permeated the osseous parieties of the tooth.

GEOSAURUS. (*Cuvier*).—At Manheim, the remains of a reptile have been discovered, which Baron Cuvier describes as more nearly related to the Lizards than to the Crocodiles; its length is estimated at about twelve feet. The eyes had a circle of osseous plates in the *sclerotica*, like those of the Ichthyosaurus; the teeth resemble those of the Mosasaurus, in being sub-compressed and recurved, but they are at once distinguished by their anterior and posterior finely serrated sharp edges; the crown is invested with an external coat of enamel.* A fine portion of the cranium, with teeth, is in the gallery of the British Museum.

RAPHIOSAURUS. (*Geol. Trans.* Vol. VI. pl. 39.)—A portion of a lower jaw, containing twenty-two closely set, subulate teeth, anchylosed by their bases to an outer alveolar parapet of bone, as in the Iguana, thus corresponding with the pleurodont Lizards, is described uuder this name by Professor Owen. It is from the Chalk near Cambridge, and is supposed to belong to the same genus as a considerable portion of a lacertian spinal column, obtained from the Chalk near Maidstone (by *Simmonds*, the well-known fossil-dealer in that town), and now in the noble collection of Sir P. Egerton, Bart., at Oulton Park. The Maidstone specimen is exceedingly fine; it consists of twenty dorsal vertebræ, with remains of numerous ribs, two lumbar,

* Oss. Foss. Tom. V. p. 343.

two sacral, and some caudal vertebræ, and the pelvic bones; the total length of the series is nine inches. The vertebræ are concavo-convex, like those of the existing lizards. The ribs are relatively long and slender, with a single head supported on a short convex tubercle or process, as in the true lizards. A beautiful lithograph of this specimen is given in the Geological Transactions. Professor Owen observes, that no vertebræ of the concavo-convex type have hitherto been observed in strata below the Chalk. I have, however, collected from the Wealden, a few vertebræ unquestionably of this form.

In the Oolite of Stonesfield, Professor Owen states that the bones of a small lizard have been found, and that the most intelligible relic is a femur "*ten lines in length*," having a hemispherical head, supported on a short sub-compressed neck, with strong trochanters at its base; the shaft cylindrical, and expanding into a broad distal extremity. (*Brit. Rep.* p. 145.)

RHYNCHOSAURUS. (*Brit. Rep.* p. 145.).—In the New Red sandstone quarries at Grinsill, near Shrewsbury, Dr. O. Ward has discovered the skull, vertebræ, ribs, bones of the pectoral and pelvic arches, portions of two femora, or thigh-bones, and fragments of other bones, of a very small, but singular reptile. The skull, with the lower jaw in its natural position, is preserved; and, together with the other bones, is described by Professor Owen with characteristic accuracy and minuteness. The general aspect of the cranium resembles that of a bird, or turtle, rather than of a lizard; for the intermaxillary bones, which are very long, curve downwards, giving the fore part of the skull the profile of a parrot. There are no teeth apparent; the margin of the upper jaw has feeble dentations, but in the lower jaw even these indications are wanting. Professor Owen remarks that "the resemblance of the mouth to the compressed beak of certain sea-birds, the bending down of the curved and elongated intermaxillaries, so as to be opposed to the deep symphysial extremity of the lower jaw, are further indications that this reptile may have had its jaws encased by a bony or horny sheath, as in birds and turtles." *

The sandstone of the New Red, in numerous places, retains the imprints of the feet of animals, that have walked over the surface of the strata when in a soft state; and foot-prints about one and a half inch long, with the mark of a hind-toe pointing backwards, are observable on the layers of stone in the Grinsill quarries, from which the remains of the *Rhynchosaurus* were obtained; they are, with much probability, supposed by Dr. Ward and Professor Owen, to have been impressed by that animal. (*Brit. Rep.* p. 146.)

THECODONTOSAURUS, (*Geol. Trans.* Vol. V.).

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* Brit. Rep. p. 150. See also Camb. Phil. Trans. Vol. VII. tab. 5, 6.

Numerous bones and teeth of reptiles occur in the Magnesian Conglomerate, near Bristol, and have been described by Dr. Riley and Mr. Stutchbury, in an interesting memoir, to which reference should be made for details. (*Geol. Trans.* Vol. V. pl. 29, 30.). The teeth of the species to which the greater part of the relics belongs, are implanted in the jaws in sockets, but the bones denote an approach to the lizards; the reptile, therefore, belonged to the group termed *thecodont*, by Professor Owen; and the name *Thecodontosaurus*, given to this extinct Saurian by Dr. Riley, has reference to this character. The teeth are pointed, compressed laterally, slightly convex on each side, with a trenchant, finely serrated edge in front and behind (see *Ly.* II. p. 100.); the fang is subcylindrical. Two teeth, possessing the same general characters, but distinguished by their much greater proportional width, are presumed to belong to another genus, named *Palæosaurus*. (*Ly.* II. p. 100, fig. 296.). The vertebræ found associated with these teeth and jaws are biconcave, and remarkably characterised by the great depth of the spinal canal, in the middle of the centrum, or body of the vertebræ; so that the spinal-marrow or chord must have presented a moniliform, or bead-like appearance. The result of the anatomical investigation of these remains, by the authors of the able memoir above referred to, is thus tersely given by Professor Owen. (*Brit. Rep.* p. 155.). These reptiles, in their *thecodont* type of dentition, biconcave vertebræ, double-headed ribs, and proportionate size of the bones of the extremities, are nearly allied to the *Teleosaurus*, (see *ante*, p. 723.); but they combine a lacertian form of tooth, and structure of the pectoral, and probably pelvic arches, with these crocodilian characters; having also distinctive modifications: such, for example, as the moniliform spinal chord.

V. PTEROSAURIANS, OR FLYING REPTILES.—PTERODACTYLUS (*wing-fingered reptile*). *Wond.* p. 49, 3. *Bd.* pl. 21, 22.—The extinct reptiles denominated *Pterodactyles*, are unquestionably the most marvellous even of the wonderful beings which the relics of the Age of Reptiles have enabled the palæontologist to reconstruct, and place before us in their natural forms and appearance. With a head and length of neck resembling those of a bird, the wings of a bat, and the body and tail of an ordinary mammalian, these creatures present an anomaly of structure as unlike their fossil contemporaries, as is the duck-billed Platypus, or Ornithorhynchus, of Australia, to existing animals. The skull is small, with very long beaks, which extend like those of the crocodile, and are furnished with upwards of sixty sharp, pointed teeth; the orbit is very large, rendering it probable that the animals were nocturnal, like other insectivora (*feeding on insects*). The fore-finger is immensely elongated, for the support of a membranous expansion, as in the Bat: and the impression of the wing-membrane is preserved on the stone in some examples; and the fingers terminated, as in that animal, in long curved claws. The size and form of the foot, leg, and thigh, show that the *Pterodactyles* were capable of perching on trees, and of standing firmly on the ground, when, with its wings folded, it might walk or hop like a bird. A reference to the graphic description of the characters and probable habits of these beings, by Dr. Buckland (*Bd.* I. p. 221.), and the beautiful illustrations accompanying it (*Bd.* II. pl. 21, 22.), will equally instruct and gratify the reader. The most perfect examples of the *Pterodactyles* have been discovered in the lithographic stone of Pappenheim and Solenhofen, where the bones of these reptiles are associated with the remains of *Dragon-flies* (see p. 574.), and other insects. In England, bones of these creatures have been obtained from the Oolitic slate of Stonesfield, from the Lias of Lyme Regis, and from the strata of Tilgate Forest. The most interesting British specimen consists of a considerable part of the skeleton of a species about the size of a Raven, discovered by Miss Mary Anning, whose indefatigable labours have been attended with such important results. This specimen (now in the British Museum) consists of the principal bones of the extremities, and of several vertebræ; it is figured and described by Dr. Buckland, *Geol. Trans.* Vol. III. pl. 27. This species is distinguished by the greater length of the claws (whence the name, *P. macronyx, long-claw,*) than in any previously known. Another remarkable character of this species, is the ossified condition of the tendons of the cervical muscles,—a peculiarity dependant on the additional support required by the long neck of this animal. The Pterodactylian remains in the Stonesfield slate, and in the Wealden grit, consist of detached long-bones, whose extreme thinness point out their adaptation for an animal capable of progression through the air; and their analogy to those of the Pterodactyles, proves that they do not belong to birds. I have a specimen of the second *phalangeal* bone of a Pterodactyle, from Stonesfield (discovered, and presented to me by the Marquess of Northampton), which must have been ten inches long when perfect.

The teeth of the Pterodactyle are simple, of a conical form, recurved, and with but little difference in their form and size. They are implanted in distinct sockets, and with wide intervals between each. In some species there are twenty-eight or thirty in the lower, and twenty-two in the upper jaw. Professor Owen states, that in the collection of the Earl of Enniskillen, there are long, slender, conical, slightly-curved, pointed teeth, from Stonesfield, which may have belonged to the large species of Pterodactyle, whose bones have been obtained from that locality by Dr. Buckland.*

* Odontography, p. 275.

VI. CHELONIAN REPTILES, OR TURTLES.—Those singular reptiles, commonly known by the name of Tortoises and Turtles, and designated by naturalists CHELONIA (from *Chelone*, the Greek term for a Tortoise), are distinguished from all other animals by the double osseous shield, or case, in which their bodies are enclosed; the head and neck, extremities, and tail, alone being excluded. This remarkable character is produced by the extraordinary development of the bones of the thorax. The breast-plate, or *plastron*, which is the true sternum, is composed of nine pieces of bone, eight of which are in pairs, and the ninth, or odd plate, is situated between the four anterior plates. The variation in the form of these plates is considerable, and affords important distinctive characters. In the young state of land and fresh-water tortoises, there are vacancies between the pieces, which are filled up in the adult, and the whole united into one bony plate; but in the marine-turtles (and also in the *Trionyces*, or soft tortoises), these pieces do not completely unite, and interspaces always remain. The bones of which the dorsal buckler, carapace, or upper shield is composed, consist of eight of the ten pairs of ribs, united by a longitudinal series of angular plates, attached to the annular part of the vertebræ throughout the whole, or a great part of their length, according to the age and species of the individual. Numerous modifications exist in the form of the buckler, in its flatness or convexity, in the degree of extension of the ribs, and their angular plates, and in the characters of the scales, or horny integument with which the carapace is covered; and with corresponding variations in the head, and in the locomotive extremities, in the numerous species and genera of the Chelonian reptiles, according to their adaptation to a terrestrial, fluviatile, or marine existence.

The animals of this order are arranged in three principal groups, viz. the marine, or Turtles (*Chelonia*); the fluviatile, or fresh-water Tortoises (*Emydes*); and the terrestrial, or Tortoises (*Testudinata*). The *Chelonia*, properly so called, are all marine, and generally feed upon vegetables; the *Emydes* are fresh-water Chelonians, which approach more nearly to the terrestrial than to the marine species; they are carnivorous, feeding on frogs, fishes, and other small animals. A division of the Emydians, called *Trionyces*, are destitute of a horny external integument, having no plates on the buckler or any other part of the body; but the osseous carapace is invested with a strong, tough skin, which equally covers the dorsum and sternum, to which it firmly adheres; the dermal surface of the bones in these Tortoises being always either granulated or covered with punctuations and depressions. The buckler of the Trionyces is of a depressed form, with a soft flattened margin, a structure enabling the animals to conceal themselves in the mud at the bottom of rivers; their food principally consists of fresh-water mollusca. The Testudinata, or land-Tortoises, are too well known to render any description requisite for our present purpose.

In the marine species, eight pairs of ribs, and thirteen plates of the longitudinal series, form the buckler; the ribs are united to each other through a great part of their extent; but towards their distal extremities each rib contracts, and terminates in a point, which is supported on a marginal series of bony plates, or scutes; the intervals between the ribs are filled up in the living animal by a cartilaginous membrane, which never becomes ossified. This character, therefore, affords an important aid in the discrimination of the fossil remains of this family.*

In the terrestrial and fresh-water Tortoises, the ossification is complete in the adult state; but in those fluviatile species, the Trionyces, which are without a horny shell, there is no border, or marginal series of bony plates or scutes, and the extremities of the ribs are therefore always distinct, and generally have an obtuse extremity. The skeletons of the three groups present corresponding modifications, and an accurate knowledge of the osteology of the recent animals is necessary to enable the palæon-

* The reader will recognise this peculiarity in the gilded skeleton of the carapace of Turtles, commonly exhibited in the soup-shops of the metropolis.

tologist to arrive at secure conclusions as to the characters and relations of the fossil species.* We can only advert to one remarkable osteological character; the construction of the shoulder, which differs from that of all other animals, in being situated within the cavity of the thorax, instead of without. In consequence of this modification, a process of the shoulder-blade (*scapula*, or *omoplate*), termed the *acromion*, is largely developed, and the shoulder-bone is tri-mucronate, or three-pronged, consisting of a short, thick head, containing a concavity (which, with that on the coracoid-bone, forms a socket for the arm-bone), and of two diverging branches. This form is so peculiar, that the collector can be at no loss to recognise the shoulder-bone of a *Chelonian*, should it come under his notice with other fossil relics (see *Foss. Til. For*. pl. 19. fig. 11.). But this shoulder-bone, and its associated coracoid-bone, undergo certain modifications, in the three groups of Turtles, by which the anatomist may pretty certainly determine the terrestrial, fluviatile, or marine character of the animals to which they belonged. The successful application of a perfect knowledge of this department of osteology,

* The student should consult *Cuvier's Ossemens Fossiles*, Tom. V. part 2[me]. chap. 2, p. 176; "*Des Ossemens de Tortue.*" The Penny Cyclopædia, Art. "*Tortoises,*" contains an excellent summary of the osteology of these reptiles; also an abstract of Professor Owen's report on "*Fossil Testudinata.*"

is admirably exemplified in the works to which reference has been made; and even but a slight acquaintance with its principles, will often enable us to obtain some general information as to the nature and relations of fossil Chelonians.

The student will remember that all the Chelonians are edentulous, *i. e.* toothless; their bony jaws being covered by horny sheaths, as in birds; these mandibles are therefore the only dental organs that can occur in a fossil state.

Fossil Turtles and Tortoises.—The earliest indications of the presence of Reptiles on our planet, are afforded by the foot-prints of Tortoises, apparently of terrestrial species, on the surfaces of the layers of sandstone of the New Red formation, in Dumfriesshire in Scotland, at Storeton, near Liverpool, and in several places in Germany (see *Bd.* I. p. 259.). But no osseous remains of Chelonia have hitherto been found in strata antecedent to the Oolite. The Solenhofen quarries have yielded the bones and carapaces of several species of marine Turtles, and remains of this family have been found at Stonesfield, and in the Bath and Portland Oolite. In the Jura limestone at Soleure, two large species of Emydians (fresh-water tortoises) have been discovered. The Wealden formation abounds in Chelonian remains of both fluviatile and marine genera. From the Isle of Purbeck some fine examples of marine and fluviatile forms have been obtained; my own researches in the strata of Tilgate Forest (*Foss.*

*Til. For.* p. 60.) have also brought to light several species, and in particular an interesting Chelonian related to the soft-skinned, fresh-water tortoises (*Trionyces; Geol. S. E.* p. 255.). In the Cretaceous formation of England the remains of these reptiles are not frequent. The Green Sand of Cambridgeshire and of Kent has yielded marine species (*Brit. Rep.* 1841, p. 172.); and in the White Chalk a few examples have been obtained, to which we shall hereafter more particularly allude. On the Continent fine examples have been found in the slate of Glaris (see *Bd.* pl. 25.); and in the upper Cretaceous strata of the Netherlands, at Maestricht, and at Melsbroeck, near Brussels, many beautiful specimens of fresh-water tortoises (*Emydes*), and marine turtles (*Chelonia*), have from time to time been obtained; these are figured and described by Baron Cuvier (*Oss. Foss.* Tom. V. pp. 236, 239.). In the Eocene strata of England, several species of Chelonians have been collected; of these five belong to the marine genus *Chelonia*, and two to the fresh-water tortoises. The Isle of Sheppey and Harwich have yielded these relics; the five species of turtles are smaller than the recent analogues, which now inhabit intertropical latitudes.* The Eocene strata of France contain several fresh-water tortoises,

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* Brit. Rep. 1841, p. 177, in which the anatomical details are given with the characteristic accuracy and minuteness of the author.

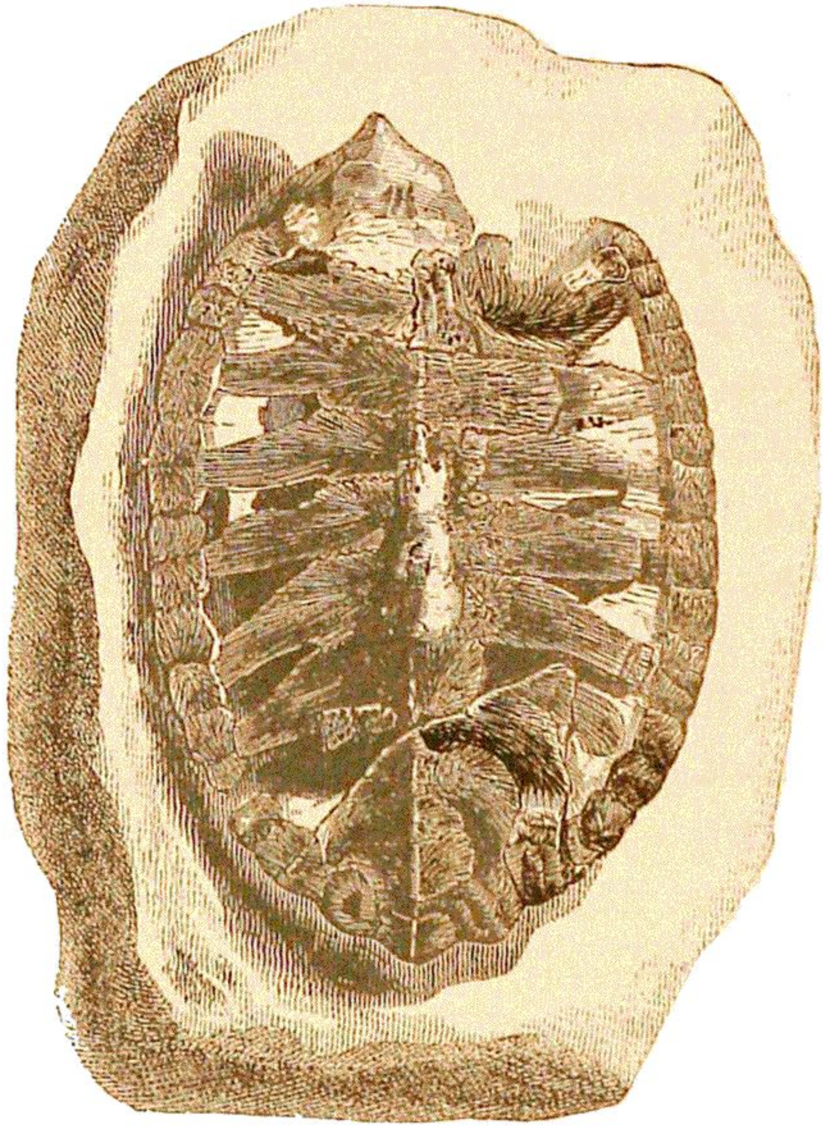
some of which are referable to the *Emydians*, and others to the Trionyces. From the gypsum beds, near Paris, the remains of one or two species of Trionyx have been obtained (*Oss. Foss.* Tom. V. p. 222.), of another at Aix, in Provence, and of three or four species in other localities. The fossil remains of *Testudinata*, or land-tortoises, are exceedingly rare. No remains of this kind are known in the British strata;* the impressions of horny scutes found in the Oolitic slate of Stonesfield, and the foot-prints above described, being the only indications of the existence of these reptiles. The presence of land-tortoises in the strata of France appears to be equally problematical, for the relics obtained from Montmartre and Aix (*Oss. Foss.* p. 245.), afford no certain data as to the character of the original. But the Tertiary formations of India have furnished decided examples of fossil terrestrial tortoises; and among the innumerable relics of the beings of an earlier world, which the indefatigable labours of Dr. Falconer and Captain Cautley have brought to light, and which those accomplished naturalists have so skilfully developed, are the remains of land tortoises of prodigious mag-

* At the head of British Chelonia (*Brit. Rep.* p. 190.), *T. Duncani* (*Owen*), is placed; but the Report does not contain the description of any Chelonian remains that can be referred to this species; and I am not aware of any other notice by Professor Owen.

nitude; one specimen, indicating a length of twelve or fourteen feet, with a breadth and height of corresponding proportions! These remains are associated with the bones of gigantic extinct mammalia, allied to the *Palæotheria* and other pachydermata of the Paris basin; and with those of *Gavials*, and other reptiles of existing species.

FOSSIL MARINE TURTLES.—In illustration of this subject, I select a fossil Turtle, discovered in the lower Chalk, at Burham, Kent, and which is remarkable for its beautiful state of preservation, the admirable manner in which the specimen is developed, and the peculiar osteological characters which it exhibits.

CHELONIA BENSTEDI. *Lign.* 144.—To Mr. Bensted, of Maidstone, a gentleman whose valuable communications I have already had occasion to acknowledge, and whose intelligence and ardent love of natural science have led to discoveries which have rendered his quarry classic ground to the British palæontologist, I am indebted for this splendid specimen. The quarry from which it was obtained presents a good section of the lower Chalk, and is situated at Burham, a short distance from the banks of the Medway, between Chatham and Maidstone. It is a locality rich in fossil remains, rivalling in this respect the quarries near Lewes, Worthing, and Arundel, in Sussex. The only relics of a Chelonian that had previously been obtained from this quarry were four marginal plates of the carapace, and fragments



LIGN. 144. FOSSIL TURTLE. *Chalk:* $\frac{1}{3}$ *nat. Kent.*

*(Discovered by W. H. Bensted, Esq.)*

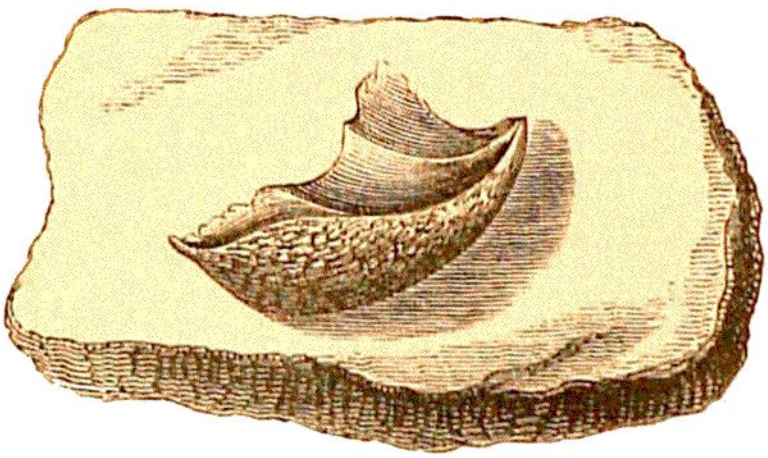
CHELONIA BENSTEDI (G. A. M.).

The dorsal shield or carapace of this specimen admits of being removed; and four sternal plates, a coracoid bone, and several vertebræ are then exposed.

of ribs;* and some marginal plates of a much larger individual, in the beautiful collection of Mrs. Smith, of Tunbridge Wells. The specimen, of which *Lign.* 144, is a reduced figure, consists of the dorsal buckler, or carapace of a young animal, almost entire, of a depressed elliptical form, with a longitudinal median ridge; it is six inches in length, and three and a half inches in breadth across the middle. It is composed of eight ribs on each side the dorsal ridge, and has a border of marginal plates. These plates are united to each other by finely indented sutures, and bear the imprints of the horny scales, or tortoise-shell, with which they were originally invested. The expanded ribs are united throughout the proximal half of their length, and gradually taper to their marginal extremities, which are supported by the plates of the osseous border. This description applies to the specimen as seen in *Lign.* 144. But Mr. Bensted has so skilfully cleared away the chalk as to admit of the removal of a great part of the dorsal shield, by which means some of the vertebræ, four sternal (*hyosternal* and *hyposternal*) plates, and one of the coracoid bones are displayed. This brief description will suffice to convey a general idea of the characters of this fossil, which differs from any known recent turtle; and possesses some anomalous features, that throw doubt as

* These are described by Professor Owen, Geol. Proc. Vol. III. p. 299.

to whether the original was an inhabitant of the sea, or of estuaries. The separate plates and fragments of ribs first found were thought by Professor Owen to indicate a fresh-water character;* and the beautiful specimen of the carapace under review, was considered by our eminent zoologist, Professor Thomas Bell, to justify a like inference; and in deference to such high authority, I described the



LIGN. 145. BEAK OR MANDIBLE OF A TURTLE: *nat. Chalk. Lewes.*

fossil as an *Emys*;† but at the same time I particularly dwelt upon the *marine character of the coracoid bone, and of the sternal plates*;‡ and lastly, Professor Owen, after a careful examination of my specimen, has arrived at the same conclusion.§

Among the numerous fossils obtained from the Chalk of the South-east of England, the only trace

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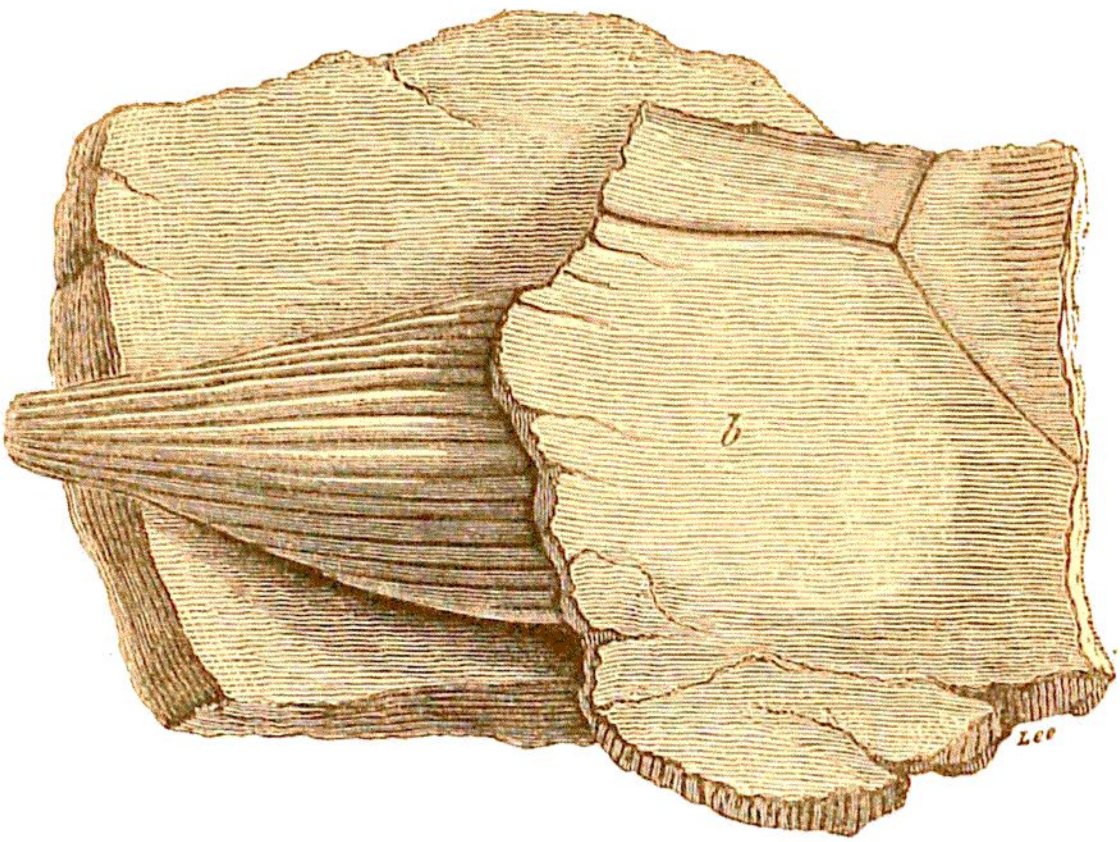
* Geol. Proc. Vol. III.

† See Phil. Trans. May, 1841, p. 153, with *two plates.*

‡ Op. cit. p. 157.

§ Brit. Rep. 1841, p. 173.

of a Chelonian reptile that has come under my observation, is the bony mandible, or beak of a Turtle, *Lign.* 145. Its surface displays a fibrous cancellated structure, denoting the attachment of the horny sheath with which, in a recent state, it was covered.




LIGN. 146. RIB OF A TURTLE: *nat.* *Tilgate Forest.*

CHELONIA BELLII* (G. A. M.).

*a.*—The striated pointed extremity of the rib.
*b.*—The distal portion of the costal plate.

CHELONIA BELLII. *Lign.* 146.—In the strata of Tilgate Forest, fragments of the carapace, and of

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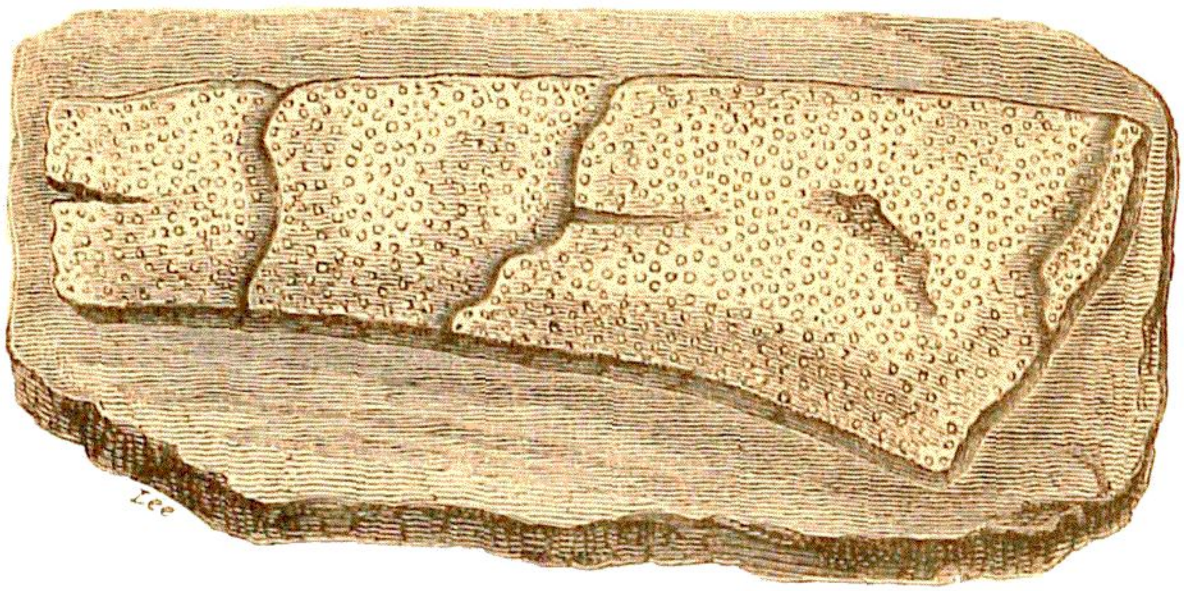
* I have named this extinct *Chelonia* in honour of my friend, PROFESSOR THOMAS BELL, the eminent zoologist.

the plastron or sternum, of the marginal scutes, and some of the bones of the extremities, of a large marine turtle have been discovered; several specimens are figured in *Foss. Til. For.* pl. 6, 7. Some examples must have belonged to an individual at least three feet in length. Unfortunately, the specimens hitherto obtained are very imperfect, and do not exhibit essential distinctive characters; with the exception of the ribs, which are united to within a short distance of their distal or marginal extremities, by which the costal interspaces are reduced to much smaller dimensions than in any recent or fossil Turtles, with which I have had the means of comparing them. The fragment of a rib, imbedded in Tilgate grit, figured *Lign.* 146, well exhibits this character.

FOSSIL FRESH-WATER TORTOISES.—The remains of fresh-water Tortoises, referable to the *Emydes*, occur in the Wealden strata, and some of these belong to the fossil species described by Baron Cuvier, and obtained from the Jura limestone (*Oolite*) of Soleure (*Oss. Foss.* Tom. V.). Among these, the most remarkable are the costal plates, and other bones of a Tortoise, which, in its essential characters, is closely allied to the Trionyces;* but differs from the recent species, in having possessed

* I discovered this species more than twenty-five years since, and pointed out its relation to *Trionyx* in *Foss. South D.* p. 47.

a dermal horny integument, formed of plates of tortoise-shell. The chelonians of the genus Trionyx (so named from their having three claws) have the



LIGN. 147. RIB OF A FRESH-WATER TORTOISE. *Tilgate Forest.*

TRIONYX BAKEWELLI * (G. A. M.).

(*Tretosternon punctatum; Owen?*)

extremities of the ribs free, and not articulated to a border of marginal scutes, and there are intervals between their costal plates even in the adult state. The external surface of the bones of the buckler is

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* This Tortoise, with the sanction of Baron Cuvier, (who, with his wonted generosity, sent me casts of the fossil Trionyx of the Paris basin for comparison,) was described under the name *Trionyx* in *Foss. Til. For.* p. 60., and its distinctive characters were pointed out. In *Geol. S. E.* p. 255, the specific name *Bakewelli*, was proposed in honour of the late ROBERT BAKEWELL, ESQ., whose excellent works have so greatly promoted the advancement of geology; a privilege to which, as the original discoverer of the species, and of its zoo-

covered with granulations, or little pits, for the attachment of the soft skin, the only integument with which these animals are invested; and being destitute of horny plates, their bones exhibit no furrows, as in the other genera. But the fossil ribs (see *Lign.* 147.) have a shagreen or punctuated surface like the recent Trionyces, and at the same time bear the imprints of horny scales; and instead of being nearly of an equal width throughout their entire length, as in the existing species, have one extremity much wider than the other, as in the land-tortoises. From the slight degree of convexity of the ribs, it is evident that the carapace was much flattened, as in the Trionyx. Except in having a defensive dermal integument, and agreeing in this respect with the Crocodilian reptiles, with which its bones are associated, the recent animal must have closely resembled the existing predaceous fresh-water soft Turtles; and, doubtless, like those reptiles, inhabited the muddy beds of lakes and rivers, preying upon the eggs and young of the larger reptiles, and on the uniones and other fluviatile mollusca, whose shells are often found imbedded with its remains.

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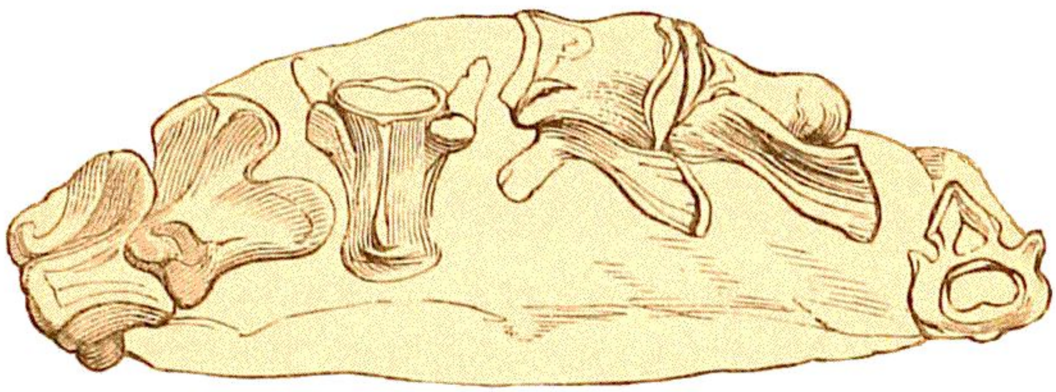
logical relations, I was fairly entitled. But this name does not appear in the list of British Chelonians, either in *Brit. Assoc. Rep.* or in Mr. Morris's *Cat. Brit. Org. Rem.* With a melancholy pleasure I now restore the name of my lamented friend, as a just, but very inadequate tribute of respect to his memory.

VII. OPHIDIANS, OR SERPENTS.—The remains of the vertebral columns of extinct Serpents, were discovered, many years since, in the London clay of the Isle of Sheppey, and specimens were obtained by the celebrated HUNTER, and preserved in his museum. These specimens, together with others in the collections of Mr. Saull, and Mr. Bowerbank, have been described by Professor Owen,* who infers,



LIGN. 148. FOSSIL VERTEBRÆ OF A SERPENT ($\frac{2}{3}$ *nat.*) Isle of Sheppey.
(*In the Museum of J. S. Bowerbank, Esq.*)
PALÆOPHIS *toliapicus; Prof. Owen.*

from the configuration of these vertebræ, and from their far exceeding in size those of any known poisonous serpents, that they belong to species allied to the Boæ and Pythons. "Serpents of such dimensions exist in the present day only in warm or tropical regions; and their food is by no means restricted to animals of the cold-blooded classes. The remains of birds and mammalia are those most

* Geol. Trans. Vol. VI. p. 209.

commonly found in the alimentary canal of such as are brought to this country dead; and living birds and quadrupeds also constitute the favourite food of the Pythons and Boæ of similar dimensions which are exhibited in our menageries."* The fossil remains both of birds and warm-blooded quadrupeds are found associated with those of Serpents in the Isle of Sheppey. From the London Clay at Bracklesham Bay, on the Sussex Coast, several ophidian vertebræ have been obtained by Mr. Dixon, and Mr. G. A. Coombe, of Arundel, that must have belonged to serpents upwards of twenty feet in length.

The vertebræ of Serpents are distinguished from those of other reptiles by a transversely oblong anterior concavity, forming a deep cup, and a corresponding posterior convexity or ball; by the interlocking of the projecting posterior oblique processes with the anterior pair; and by the oblong tubercle on each side of the anterior part of the body of the vertebra, for moveable articulation with the head of the ribs; a spinal column thus constructed combines in the highest degree perfect flexibility with great strength.

In addition to the specimens above referred to, fossil vertebræ of a small serpent have been found in the Red Crag at Kyson in Suffolk;† a locality that has yielded other organic remains of great

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* Geol. Trans. Vol. VI. p. 209.

† Brit. Rep. 1841, p. 181.

interest. The only fossils of this order of reptiles previously described, are some vertebræ of serpents from the bone-breccia of Cette (*Oss. Foss.* Tom. IV. p. 177.).

VIII. BATRACHIANS.—The reptiles termed BATRACHIANS (from the Greek name for Frog), are characterised by the metamorphoses which they undergo in the progress of their development from the young to the adult state; the Frog, Toad, and Newt, are familiar examples of this order. Their organs of aerial respiration consist of a pair of lungs; but in their young state they are provided with gills, supported, as in fishes, by cartilaginous arches. These organs disappear in most species, when the animals arrive at maturity; but in a few genera, as the *Siren* and *Proteus*, they are persistent. The skeletons of these reptiles present corresponding modifications. The skull is, for the most part, much depressed, and the cerebral cavity small; it is united to the vertebral column by *two* distinct condyles, situated on the sides of the occipital or cranio-spinal aperture. The vertebral column, which in some genera (as for example, in the frog) is very short, and reduced to eight or ten bones, is composed, in the higher organized Batrachians, of concavo-convex vertebræ, as in the Crocodile; but in the lower type, as the Siren, Proteus, and Axolotl, the vertebræ are biconcave, as in numerous species of fossil Saurians. The ribs are merely rudimentary; a condition which has relation to the mode of reproduction in these animals.* Some of the Batrachians are edentulous, like the Turtles, but others have numerous small, conical, uniform, closely-arranged teeth, placed either in a single row, or aggregated like the rasp-teeth in fishes.†

FOSSIL BATRACHIANS.—The skeletons, vestiges of the soft parts, and imprints of the feet of several genera of Batrachians, occur in a fossil state, in tertiary deposits, all of which, like the existing races, appear to belong to fresh-water or terrestrial species. In the pliocene, or recent tertiary strata, on the banks of the Rhine, at Œningen, and in the *papierkohle* of the Eifel, several species of Frog, Toad, and Newt, have been discovered.

A celebrated fossil of this class is the gigantic Salamander, three feet in length (*Wond.* p. 495.), found at Œningen (see *Wond.* p. 250.), which a German physician of some note (*Scheuchzer*) supposed to be a fossil man!‡ and described it in an essay entitled "*Homo Diluvii testis,*" as being the moiety, or nearly so, of a human skeleton, with the bones and flesh incorporated in the stone.§ A fine example

* See Dr. Roget's Bridgewater Essay, p. 395.

† The variations in the dental system of these animals are described in detail by Prof. Owen; Odontography, Chap. II. p. 187.

‡ Phil. Trans. for 1726, Vol. XXXIV.

§ An admirable illustration of this highly interesting fossil is given by Baron Cuvier, *Oss. Foss.* Tom. V. p. 431.

of this fossil Salamander is preserved in the British Museum.

But by far the most interesting evidence of the existence of Batrachian reptiles in the earlier ages of our planet, has been afforded by Professor Jæger's discovery of the skull, teeth, and other remains of gigantic extinct animals allied to the Salamander, in the New Red sandstone (*Keupersandstein*) of Wirtemberg.*

By a mistake, incidental to a first attempt to develope the mutilated relics of unknown types of structure, these remains were referred by this eminent physician and naturalist, to three different genera of saurians, although the double condyle on the occipital bone revealed the Batrachian affinities of this gigantic reptile. It was reserved, however, for our distinguished countryman, Professor Owen, to correct the error into which the German *savant* had fallen—remove the obscurity in which the subject was involved—determine the natural relations of the original, and develope a modification of dental organization of the most unexpected and interesting character.

Dr. Lloyd, of Leamington, having discovered several fossil teeth in the light-coloured sandstone of the New Red, at Warwick and Leamington, submitted

* Über die Fossile Reptilien welche in Würtemberg aufgefunden worden sind. Von Dr. Geo. Friedr. Jæger. Stuttgart, 1828.

them to Professor Owen, who, struck with their general resemblance to the teeth of the gigantic Salamander of Wirtemberg, instituted a microscopic examination of the British and German specimens. The result proved that the teeth from both localities possessed a remarkable and complicated structure, produced by the convergence of numerous inflected folds of the external layer of cement towards the pulp-cavity; to which, as we have already seen (p. 710.), a very slight approach was made in the fang of the tooth of the Ichthyosaurus, and a still closer approximation by the teeth of certain fishes (*Lepidosteus*, p. 651.). From the intricate meanderings or labyrinthine inflections observable in the sections of these teeth, Professor Owen has given the name of *Labyrinthodon* to these extinct Batrachian reptiles, and has determined five British species; one of which (*L. salamandroides*) he conceives to be identical with a species described by my friend, Dr. Jæger.

The remains of the skeletons of these reptiles, hitherto found in Warwickshire, consist of portions of the cranium, and of the upper and lower jaws, with teeth, vertebræ, a sternum, some of the bones of the pelvis, and of the extremities. From a specimen (of *L. scutulatus*) consisting of an aggregated group of bones, imbedded in sandstone, comprising four vertebræ, portions of ribs, a humerus, a thigh-bone, and two leg-bones, with several small *osseous scutes*, it appears that one species, at least, resembled the

Crocodiles in its dermal structure. But Professor Owen remarks, that this modification of the dermal system does not affect the claims of the Labyrinthodonts to be considered as Batrachians, although all the known living species of this order are covered with a soft, lubricous, naked integument; for the skin is the seat of the most variable characters in all animals; and the double occipital condyle, the simple lower jaw, the palatal vomerine bones, and the teeth of the fossil reptiles, must be deemed decisive of their essentially Batrachian nature.

From the structure of the cranium the important fact is established, that the Labyrinthodonts had subterminal nostrils leading to a wide and shallow nasal cavity, separated by a broad and almost continuous palatal flooring from the cavity of the mouth; indicating, by its horizontal position, that the posterior apertures were placed far behind the external nostrils; whereas in the recent air-breathing Batrachians the nasal canal is short and vertical, and the inner apertures pierce the anterior part of the palate. Hence the Labyrinthodonts must have breathed air like the Crocodiles, and were probably provided with well-developed ribs, and not mere rudimentary styles, as in most living Batrachians.

TOOTH OF THE LABYRINTHODON. Pl. VI. fig. 3.—The tooth of the Labyrinthodon is of a conical figure, very slightly recurved, and marked externally with shallow, fine, longitudinal striæ. Pl. VI. fig. $3^a$. represents (½ *nat.*) a specimen presented to me by

Dr. Jæger. The tooth is implanted by a simple fang, in an alveolar groove to which it is anchylosed. It consists of a simple central pulp-cavity, surrounded by a body of dentine, which has an external thin coat of cement; and a vertical duplication, or fold of this cement, penetrates the substance of the tooth at each of the striæ, which are arranged at intervals of about one line, around the entire circumference of the tooth. The inflected folds of cement extend inwards towards the centre, in a straight direction, for about half a line, then become undulated, and finally terminate in a dilatation or loop, close to the pulp-cavity, from which it is separated by a thin layer of dentine. Within these inflections of the cement, the dentine, or tooth-bone, is similarly disposed; a layer of dentine lining the folds of cement, and having corresponding interspaces, which are filled up by the processes from the pulp-cavity. Pl. VI. fig. 3[a.] represents a transverse section of half the diameter of the tooth; the vacancy in the middle of the line at the bottom is a section of half the pulp-cavity. Fig. 3[b.] is a vertical section of a fragment near the summit of the tooth; and fig. 3[c.] a highly-magnified view of one of the anfractuosities, showing a fold of cement, surrounding a fold of dentine, and in the centre of the latter the termination of a process of the pulp. The section of the tooth of the Ichthyosaurus, Pl. VI. fig. 9, shows the most simple modification of this structure; the apparent complication of that of the Labyrinthodon, arises from the inflections of the three elements of dental organization being more numerous and diversified. But the beautiful plates, and graphic description of the original discoverer, must be seen and perused to obtain an adequate idea of the exquisite structure of these fossil teeth; for the distribution of the extremely minute calcigerous tubes of the dentine is as diversified as that of the constituent substances. And even after viewing these *chefs-d'œuvres* of structural delineations, should the student have an opportunity of examining a transverse section of a tooth under the microscope, he will feel how feebly any engraving can represent the characters of the original.* Professor Owen's memoir on the Labyrinthodonts, in *Geol. Trans.* Vol. VI. p. 503—543, with five admirable lithographs by that excellent artist, Mr. Scharf; and the description of the structure of the teeth, ODONTOGRAPHY, p. 195, pl. 63, 64; should be consulted.

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ON COLLECTING THE FOSSIL REMAINS OF REPTILES.—The length to which this article has extended, compels me to omit a retrospect of the geological distribution of fossil reptiles; and I must

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* I can never forget the astonishment and delight with which Dr. Buckland, Professor Agassiz, and myself, observed, for the first time, the marvellous structure of the tooth of the Labyrinthodon, displayed to us by Professor Owen, before his splendid discovery was communicated to the scientific public.

refer the reader to the brief review of the Age of Reptiles in *Wond.* p. 497, and close this chapter with some directions for collecting reptilian remains, and a list of a few British localities.*

The fossil *Teeth of Reptiles* are commonly found in as perfect a state of preservation as those of fishes; and require but the usual care for their preservation. But the collector should assiduously search for vestiges of the jaw and cranium; and it is desirable to place in the same drawer any undetermined bones found associated with the teeth; as they may ultimately afford some clue to the nature of the original animal. The microscopical examination of the teeth is to be conducted in the manner previously directed (p. 78.); but for valuable specimens the lapidary should be employed, and transverse sections made from near the apex, the middle, and base of the tooth; if due care be taken, several slices may be obtained from one specimen. I have ten slices from one tooth of the Labyrinthodon. The bones imbedded in limestone generally partake of the chemical character of the rock, and are often permeated with calcareous spar; mere fragments, when polished, frequently display the internal structure.

The suggestions for repairing fossil bones (pp. 56—62.) render further instructions on that head

* An able Summary on British Fossil Reptiles is appended to Prof. Owen's report, *Brit. Rep.* 1841, p. 191.

unnecessary; and the description of the development of the specimen of Hylæosaurus (p. 735.), affords a practical lesson to the young collector.

When a vertebra is found in an imperfect state, it should be closely examined on the spot, and if it present proofs of recent fracture, the detached processes should be sought for; even if the body of a vertebra be imbedded in stone, and the processes appear to have been broken off before it was enveloped in the rock, the corresponding parts will often be found in the same mass of stone. There is, in the British Museum, a very fine Saurian vertebra imbedded in a large slab of Tilgate limestone, in which the spinous process is seen lying in the same block, several inches distant from the centrum, or body: when observed in the quarry the latter only was exposed, and I was about to detach it from the slab, for the convenience of carriage, when I perceived indications of the spinous process. The vertebra was therefore allowed to remain, and the stone chiselled away, so as to expose the spine; and the specimen then displayed its present interesting character.

It may frequently happen that a fragment of a large bone,—as, for example, the thigh-bone of the Iguanodon,—may be obtained from a quarry; and after an interval of some weeks, the corresponding portions be discovered. This was remarkably exemplified in the first specimen, which revealed to me the peculiar characters of the femur of the Iguanodon. The lower part, or condyloid extremity of a gigantic bone, firmly impacted in a block of Tilgate-grit, was found in a quarry near Cuckfield: it was evidently but a fragment of the fossil, for the fracture was recent; I therefore requested the quarry-men to make diligent search for the corresponding portion, but without success. Several months afterwards, upon a fresh explosion in the quarry, the head of a large bone was found loose among the fallen mass; but there were no indications that it belonged to the specimen previously found; and it was regarded as another relic of some one of the colossal animals whose bones were distributed in the Wealden deposits. Teeth, fragments of bones, and other fossils, were from time to time obtained from the same quarry; and among these a huge quadrangular fragment of bone, similar to the enormous mass that had so long been in my possession, and had defied all attempts to ascertain its character.* It was some time before it occurred to me, that the three portions of unknown colossal bone, might belong to the same specimen; but eventually they were found to correspond, and upon cementing them together, the femur of the Iguanodon was, for the first time, developed.†

The figures in *Lign.* 138 will enable the collector to recognise the different vertebral processes, even

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* The fragment alluded to is figured, *Foss. Til. For.* pl. 18.

† See *Wond.* Pl. III. fig. 11: *d* marks the fragment first

when occurring as detached fragments. When specimens are evidently rolled or water-worn, there is, of course, no probability that the corresponding portions will be met with. Every fragment of a bone, the nature of which is not obvious, should be carefully preserved; for, sooner or later, its characters may be ascertained. It is scarcely necessary again to remind the collector, that search should be made for indications of the soft parts around the bones; the specimen of the paddle of the Ichthyosaurus (*Lign.* 141, p. 713.), with its integument, must have impressed this fact too strongly on the mind to be soon forgotten. If the impression of the extremities of a bone, of which a fragment only remains, be observed, the block of stone should be preserved, as a cast may be taken, and the entire form of the original be ascertained.

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## BRITISH LOCALITIES OF FOSSIL REPTILES.

Aust Cliff, near Bristol. *Lias.* Plesiosaurus.

Barrow-on-Soar. *Lias.* Ichthyosaurus, Plesiosaurus.

Bath. *Oolite* and *Lias.* Plesiosaurus.

Battle, Sussex. *Wealden.* Iguanodon, Cetiosaurus. Goniopholis, Chelonians.

Binstead, Isle of Wight. *Tert.* Fresh-water Tortoises.

Bolney, Sussex. *Wealden;* in the stone-pits. Hylæosaurus, Iguanodon, Chelonia, Goniopholis.

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discovered; *a*, the second specimen, which includes the head of the bone, with its trochanter; *b*, the middle portion of the shaft, with its compressed median process.

Bracklesham Bay. *Tert.* Crocodiles, Serpents, Turtles.

Brighton. *Chalk.* Vertebræ of Mosasaurus, or Leiodon; *very rare.*

Bristol. *Lias.* Ichthyosaurus.

——— *Magnes. Conglomerate. Thecodontosaurus*, p. 761.

Brook-Point, Isle of Wight. *Wealden.* Iguanodon, Cetiosaurus, &c.

Burham, near Maidstone. *Chalk.* Chelonia, Lacerta, &c.

Burwash, Sussex. *Wealden;* quarries in the neighbourhood. Goniopholis, Turtles.

Cambridge. *Lower Chalk.* Raphiosaurus. Polyptychodon.

Charmouth. *Lias.* Ichthyosaurus.

Cheltenham. *Lias.* Ichthyosaurus.

Chipping Norton. *Oolite.* Streptospondylus.

Corn-Cockle Muir, Dumfries. *New Red.* Imprints of feet of Tortoises.

Coton-End, Warwickshire. *New Red.* Labyrinthodon.

Cubbington, Warwickshire. *New Red.* Labyrinthodon.

Cuckfield. *Wealden:* quarries in the vicinity. Iguanodon, Hylæosaurus, Trionyx, &c.

Culver Cliff, Isle of Wight. *Wealden.* Streptospondylus.

Garsington, Oxfordshire. *Oolite.* Cetiosaurus.

Glastonbury. *Lias.* Ichthyosaurus.

Grinsill, Warwickshire. *New Red.* Rhyncosaurus.

Guy's Cliff, Warwick. *New Red.* Labyrinthodon.

Harwich. *London Clay.* Chelonia.

Hastings. *Wealden.* Iguanodon, Goniopholis, Turtles.

Horsham, Sussex. *Wealden*; quarries in the vicinity. Hylæosaurus, Iguanodon, Goniopholis, Turtles, &c.

Heddington, Oxfordshire. *Kimmeridge Clay.* Pliosaurus.

Kyson, Suffolk. *London Clay.* Crocodiles.

Leamington. *New Red.* Labyrinthodon.

Lewes. *Chalk.* Vertebræ of Mosasaurus, or Leiodon; *very rare.*

Lyme Regis. *Lias.* Pterodactyles, Ichthyosauri, and Plesiosauri in abundance.

Maidstone. *Shanklin Sand;* quarries near the town; particularly Mr. Bensted's "*Iguanodon quarry.*" Iguanodon, Plesiosaurus, Turtles, Polyptychodon.

Malton. *Oolite.* Megalosaurus.

Market-Rasin. *Kimmeridge Clay.* Pliosaurus.

Norfolk. *Chalk.* Leiodon; *very rare.*

Portland, Isle of. *Oolite.* Turtles.

Purbeck, Isle of. *Wealden.* Goniopholis, Turtles.

Redland, near Bristol. *Magnesian Conglomerate.* Palæosaurus.

Saltwick. *Lias.* Teleosaurus.

Sheppey, Isle of. *London Clay.* Turtles, Serpents, Crocodiles.

Shotover, near Oxford. *Kimmeridge Clay.* Pliosaurus, Teleosaurus.

Stonesfield. *Oolite.* Megalosaurus, Teleosaurus, Pterodactyles.

Storeton, Cheshire. *New Red.* Foot-prints of supposed reptiles (*Cheirotherium*).

Street, Somersetshire. *Lias.* Ichthyosauri and Plesiosauri.

Swanage, Isle of Purbeck. Goniopholis, Turtles.

Tilgate Forest. *Wealden:* quarries in various localities. Iguanodon, Hylæosaurus, Suchosaurus, Turtles, and Tortoises.

Watchet, Somersetshire. *Lias.* Plesiosauri, Ichthyosauri.

Warwick, Guy's Cliff, near. *New Red.* Labyrinthodon.

Westbrook, Wilts. *Kimmeridge Clay.* Ichthyosaurus.

Weston, near Bath. *Lias.* Plesiosaurus.

Whitby, Yorkshire. *Lias.* Ichthyosauri and Plesiosauri. Teleosaurus.

Wight, Isle of; along the southern shore, near Brook-point. *Wealden.* Iguanodon, Cetiosaurus, &c., washed up on the sea-shore.

# CHAPTER XIX.

## ORNITHOLITES, OR FOSSIL BIRDS.

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EXCEPT in strata of comparatively modern origin, the remains of Birds are of extreme rarity in a fossil state. In the caverns that contain the skeletons of carnivorous animals, and which were once their dens, and are now their sepulchres, the bones of several species of existing genera of Birds have been discovered, in England, on the Continent, and in Australia; and very recently there have been obtained from alluvial deposits in New Zealand, the skeletons of Birds of enormous magnitude, and under conditions which leave some doubt whether, like the *Dodo*, the species may not have been extirpated by man during the last few centuries; or even if some stray individuals of the race may not, according to the belief of the aborigines, be still in existence in the interior of the country.

From the gypsum quarries at Montmartre, near Paris, Baron Cuvier obtained several species of Ornitholites; and these fossil birds of the eocene tertiary deposits were the most ancient relics of this class known to the geologist, until the discovery of a few bones of *Waders* in Tilgate Forest (*Foss. Til. For.* pl. 8.); and which are still the earliest evidence hitherto obtained of the existence of Birds, with the exception of the foot-prints on the *New Red* sandstone of North America.

The rarity of the remains of Birds may probably in some measure be attributable, as Mr. Lyell has suggested, to the peculiar organization of these animals; for their power of flight necessarily renders them less liable to be engulphed and imbedded in the deltas of rivers, or in the bed of the ocean, than quadrupeds; and the lightness of their structure, occasioned by their tubular bones, and feathery dermal integument, generally prevents the sinking of the bodies of such as die on, or fall into, the water, until their carcases are devoured, or decomposed.

In illustration of this subject, I purpose, in the *first* place, to explain such peculiarities in the osteology of the animals of this class, as may assist the collector in the identification of their fossil remains; *secondly*, to take a cursory survey of the geological distribution of fossil BIRDS, and examine a few of the most interesting examples; and *lastly*, consider the striking phenomena presented by the foot-prints of supposed Birds on the strata of those ancient deposits, which are comprised in the *Trias*, or New Red formation.

I. Osteological Characters.—The skull in birds presents this remarkable feature, that it is composed of but one bone without any trace of suture. The lower jaw is united to the skull by the intervention of a bone (*os quadratum*), as in certain reptiles. Both jaws are destitute of teeth, and are protected by dense horny sheaths, which form powerful dentary organs. The vertebral column of the neck is exceedingly flexible, and composed of a greater number of bones than in any other living animals; for the cervical vertebræ, which in the mammalia amount to seven, in birds vary from ten to twenty-four, as in the Swan. To admit of this extreme mobility of the *neck*, without injury to the enclosed spinal marrow, the annular part, or neural arch, of each cervical vertebra is enlarged at the extremities that form a junction with the corresponding bones; thus presenting a modification of vertebral development directly the reverse of that possessed by the extinct saurian of the Magnesian conglomerate (see p. 761.). The dorsal and sacral vertebræ, on the contrary, are firmly interlocked and often anchylosed together, and constitute a strong, inflexible pillar, to afford a fixed point of support to the powerful locomotive organs of flight. The ribs are formed so as to combine strength with lightness in the construction of the walls of the chest, for each rib has a *recurrent apophysis*, or process, that extends backwards, and glides over the contiguous bone; and this is a very peculiar and obvious character. The ribs are united in front to the sternum by bony processes, somewhat analogous to the *costal-arcs* of the Plesiosaurus. The pectoral arch is distinguished by the prominent longitudinal keel or crest of the sternum; a structure designed to give attachment to the powerful pectoral muscles which move the wings, and which presents characteristic modifications in the different orders; and by the peculiar bone, termed the *furcula*, or merry-thought, which connects the clavicles. The bones of the anterior extremities are modified to adapt these instruments for the purposes of flight, and those of the fore-arm (the *radius* and *ulna*) are very long and firmly united together; the ulna has a row of slight eminences for the attachment of the quills of the secondary feathers. The wrist, or *carpus*, is composed of but two bones, articulated to the radius and ulna, and which admit only of a *lateral* movement, by which the wings are folded close to the body. The bones of the hinder extremities consist of the thigh or *femur;* the leg-bones, *tibia* and *fibula*, the latter very small, and anchylosed to the former; and of a *single shank-bone*, which supplies the place of the tarsal and metatarsal bones of other animals. This bone is articulated at its upper extremity to the tibia, and terminates at the lower end in distinct processes, which correspond in number with the toes; each process having a groove for the pulley or tendon that moves the corresponding toe. This construction is peculiar to birds; for although in some quadrupeds, as the horse for example, the metatarsus consists of but one piece, the tarsus is composed of several bones.

The toes of birds present deviations equally recognisable; for the number of the articulations (or pieces of bone) in each toe is different. Thus the thumb, or short-toe, has *two* bones; the first toe on the inner side *three;* the middle toe *four;* and the outer toe *five*. In general, three toes are directed forwards, and one backwards. In some species, the thumb or opposable toe is altogether wanting; in others, as in the swallow, it is directed forwards; in climbing birds, both the outer and back toe are situated behind. The position of the hind toe, therefore, affords an important indication of the habits of the bird (see *Wond.* p. 135, Tab. 22.), and from a fragment of the lower extremity of the shank, or tarso-metatarsal bone, with any trace of this articulation, we may determine whether the individual to which it belonged was a climber, wader, &c. In the toes of Crocodiles alone, the number of joints is the same as in birds; but in these reptiles, each toe is supported by a distinct metatarsal bone. The osteological peculiarities above enumerated, may assist the collector in arriving at some general inferences as to the nature of any fossil remains of birds.

## II. Ornitholites of Tertiary Deposits.

*Wond.* p. 238.—The fossil remains of birds consist in general of their osseous skeletons, and of detached bones; and rarely of the feathers and eggs. From the quarries of gypseous limestone of Montmartre, near Paris, Baron Cuvier obtained many bones, and some connected portions of the skeletons of several birds related to the Pelican, Sea-lark, Curlew, Woodcock, Owl, Buzzard, and Quail.* In several of these examples there are the imprints and remains of the quills and feathers; in some the skeleton has perished, and a pellicle of dark-brown substance, with the configuration of the original, alone remains (see *Wond.* p. 238.). These Ornitholites are associated with the bones of the Palæotheria, and other extinct mammalia of the eocene period. Two or three Ornitholites have been discovered at Montmartre, in which almost the entire skeleton is preserved. In one example, described by Baron Cuvier, the remains of a bird are displayed in such a manner as to render it probable that the animal had fallen on its belly, and become partially impacted in the surface of the soft gypsum, which is now become solid stone; and that, previously to its being completely enveloped, the principal part of its head and the left leg were removed by the agency either of some voracious animal, or by the action of the water. In addition to the other parts of the skeleton, the under side of the bill is very distinctly impressed on the stone, and the left branch is entire; there are also

* Ossemens Fossiles, Tom. III. p. 302, pl. 72—75.

the remains of the cellular basis of the skull; and both the wings are well preserved. Nine or ten species of fossil birds were identified by Baron Cuvier from the Paris eocene strata.

Three or four species of Ornitholites, and several examples of the eggs of aquatic birds, have been discovered in the lacustrine strata of Cournon, in Auvergne. Bird's bones also occur in the fresh-water limestone near Issoire, in the Puy de Dôme, associated with the remains of eocene mammalia.

LITHORNIS VULTURINUS. *Geol. Trans.* Vol. VI. pl. 21.—Under the name of Lithornis (*fossil-bird*), Professor Owen has described the fossil remains of a bird, consisting of two most characteristic bones,—the sternum and sacrum,—and fragments of other bones, obtained from the London Clay of the Isle of Sheppey. These relics present the closest agreement with the corresponding bones of the Vulture tribe, but indicate a smaller species of Vulture than any now known to exist. In the Crag of Norfolk and Suffolk, fossil bones of birds have been discovered, but no accurate determination of their characters has hitherto been published.*

ORNITHOLITES OF THE CAVERNS.—Many limestone districts abound in fissures and caves, which

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* This desideratum will doubtless soon be supplied by a work now in progress of periodical publication, "A History of British Fossil Mammalia and Birds," by Professor Owen.

vary in extent from mere superficial hollows to deep excavations, and caverns of considerable magnitude. (*Wond.* p. 417.). Beneath the stalagmitic or sparry floors, and walls of some of these caverns, the bones of extinct species of Bears, Lions, and Hyenas, occur in immense quantities; but the full consideration of these phenomena will be reserved for the next chapter. The skeletons and detached bones of several kinds of Birds are often found imbedded with these remains; and under circumstances which seem to indicate that they were brought into these caverns as prey by the carnivora, with whose relics they are now associated. Some examples show that the birds had fallen into the fissure; others, that their bones had been transported to their present situation by the action of water.

In the Cave of Kirkdale, in Yorkshire (*Wond.* p. 169.), Dr. Buckland found bones of a species of Raven, Lark, Pigeon, Duck, and Snipe; and as almost all the specimens were the remains of wing-bones, it is considered probable that they are the relics of dead birds, which had been brought into the cave by the hyenas, whose den it is supposed to have been for a considerable period.*

It is an extraordinary fact, that among the innumerable remains of vertebrated terrestrial animals, which have been discovered in the drift, or ancient alluvial deposits of Europe, scarcely any

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* RELIQUIÆ DILUVIANÆ, p. 34.

vestiges of birds have been discovered. Dr. Buckland states that some bones, apparently of a species of goose, found with the remains of an Elephant and Rhinoceros, is the only instance he has met with of fossil birds in the drift of England.*

Some bones of the Dodo † (see *Wond.* p. 119), a bird which appears to have become extinct by human agency, within the last two centuries, are said to have been found, associated with the remains of a recent species of Tortoise, beneath a bed of lava in the Isle of France. And in some caverns in the island of Rodriguez, the bones of a large bird, supposed to be the Dodo, have also been discovered.

Ornitholites of the Chalk.—In the White Chalk of Kent and Sussex, five or six fragments of bones have been found, which evidently belong to birds. Those from Sussex are too imperfect to admit of any approximative conjecture as to their affinity with recent species; but three bones from Burham Chalk-pit, near Maidstone (in the collection of the Earl of Enniskillen), afford certain available characters; these have been examined by Professor Owen, and are figured and described in *Geol. Trans.* Vol. VI. pl. 21. One of these specimens is a long bone, nine inches in length, slightly bent, with one

* Reliquiæ Diluvianæ, p. 27.

† An excellent account of the Dodo will be found in the Penny Cyclopædia, *Art.* Dodo.

extremity tolerably perfect and expanded; but the other end is destroyed. The shaft of the bone is two and a quarter inches in circumference, and of nearly equal size throughout; it is irregularly trilateral, the sides being flat, and the angles rounded. This specimen, Professor Owen observes, differs from the femur of any known bird in the proportion of its length to its breadth; and from the tibia, or metatarsal bone, in its trilateral form, and the flatness of the sides, some of which are longitudinally grooved. It resembles most the *humerus* of the Albatross in its form, proportion, and size; but it differs in the angles bounding the three sides being more strongly marked. The other portions of bone support the inference, that these relics belong to a species of *Albatross:* there is no bird now known north of the Equator, to which the fossils bear any close relation.*

ORNITHOLITES OF THE WEALDEN.—Among the earliest discovered fossil bones in the Wealden of the South-east of England, collected from the strata of Tilgate Forest, were several framents of such extreme tenuity as could only have belonged to animals capable of transporting themselves through the air; and some of the specimens so closely resembled the tarso-metatarsal, or shank-bones of Waders (*Grallæ*), that I was led to consider them as affording indisputable evidence of the existence

* Geol. Trans. Vol. VI.

of birds allied to the Heron, in the Country of the Iguanodon (see *Foss. Til. For.* pl. 8.). But as the Stonesfield slate contained thin and delicate bones, also referred to Birds, and which the sagacity of the late Mr. Miller proved to belong to Pterodactyles, or flying reptiles, doubts were raised as to the correctness of my determination of the Tilgate specimens; and a distinguished palæontologist declared that there was no certain evidence of the fossil remains of Birds in any strata more ancient than the Tertiary; for the existence of Ornitholites in Chalk was then unknown. On the last visit of the late Baron Cuvier to England, I submitted my supposed Birds' bones from Tilgate Forest, to the examination of that illustrious philosopher, who unhesitatingly confirmed my opinion that the bones belonged to some wader; and probably to a species of *Ardea*, or *Heron*. Subsequently, Professor Owen had the kindness to examine the specimens in my possession, and arrived at the same conclusion. Unfortunately, no perfect bone has been discovered, and but one example possesses very decided characters; this is a portion of a shank-bone, in which the position of the hind-toe is indicated by an oval cicatrix, and demonstrates the order of birds to which the bone belongs. On this interesting relic, which is accurately figured in *Lign.* 149, Professor Owen favoured me with the following remarks:—

"This fragment is undoubtedly the distal extremity of the left tarso-metatarsal bone of a Bird. The oval spot (*a*)


LIGN. 149. FOSSIL SHANK-BONE OF A BIRD ALLIED TO THE HERON: *nat. Tilgate Forest.*
PALÆORNIS CLIFTII * (G. A. M.).
*a.*—The elliptical surface for articulation with the hind toe.
*b.*—Ridge for the attachment of the sheath which braces down the tendons that pass to the toes.

* As the Wealden Ornitholite has hitherto received no generic appellation, I propose that of PALÆORNIS *(ancient bird);* and would distinguish the species by the term *Cliftii;* as a tribute of respect to that excellent man, and profound anatomist, WILLIAM CLIFT, Esq., Curator of the Hunterian Museum; to whose valuable assistance in the identification of fossil remains, so fully granted upon every occasion, British geologists, and especially the Author of these volumes, are deeply indebted.

denotes the articular surface or place of attachment of the posterior or opposable toe; and is a mark of more than ordinary importance, since much may be deduced of the habits of the Bird by observing the relative situation of this cicatrix to the articular surfaces of the other toes. Thus in a scansorial, or climbing bird, it is placed nearly on a level with the others, that the back-toe may be effectually opposed to the fore-toes; and the same obtains in the raptorial birds, for seizing their prey. I infer that this specimen belonged to a wader, and that the back-toe was a long one; and adapted for supporting the body on a marshy soil. The thin longitudinal ridges of bone in the fossil (*b*), also agree with what may be observed in the metatarsals of birds; they afford attachment to the aponeurotic thecæ *(membranous sheaths)* which tie down the tendons as they glide along the metatarsus to the toes. As the soft articular extremity of the bone has been destroyed, it is probable that the Bird was young, and the epiphysis not anchylosed."

Another fragment Professor Owen was of opinion resembled the head of a humerus of a bird, and a third specimen, the proximal head of a tibia; and he observed that in some of the long bones from Tilgate Forest, there are longitudinal grooves which accord with what is observable in the metatarsals of birds; but that similar grooves appear also to characterize most of the long bones of Pterodactyles.*

On one fragment of bone, apparently of an *ulna*,

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* Memoir on the Bones of Birds discovered in the Strata of Tilgate Forest; by the Author. *Geol. Trans.* Vol. V. Second Series, p. 175.

a row of small eminences remains; probably the points of attachment for the quills of the secondary feathers of the wing.* The *Palæornis* appears to be distributed throughout the Wealden strata; for I have found fragments of bones in several localities, as for example, at Hastings, Battle, Cuckfield, and Horsham.

III. ICHNOLITHES *(foot-prints on stone.)*.—With these few proofs of the presence of Birds during the "*Age of Reptiles*," ceases all positive evidence of the existence of this highly organized class of vertebrated animals in the Secondary strata. But a most unexpected and remarkable discovery has been made by an eminent physician, Dr. James Deane, of Greenfield, which seems to prove incontestably that numerous birds, and some of gigantic size, existed at the period when the Triassic, or *New Red* strata, were in the progress of formation; that period, as the reader will remember, in which the Labyrinthodonts, and other extraordinary reptiles, flourished. Allusion has already been made to foot-prints, supposed to be those of land tortoises (see p. 769.) on slabs of Triassic sandstone

* As the fossils to which reference is made in the text have been transferred, with the rest of my collection of organic remains, to the British Museum, I have not been able to confirm or modify the inferences formerly made, by a re-examination of these specimens.

in Scotland. The imprints of the feet of some large quadrupeds, having the fore-paws much smaller than the hinder, have been found in Saxony (see *Wond.* p. 478. *Bd.* p. 26.); and also in strata of the same age in Warwickshire and Cheshire. The quarries at Storeton Hill, near Liverpool, are celebrated for the abundance and variety of these imprints. Some of the strata of sandstone in this locality are divided by thin beds of clay; a lithological structure which admits of the ready separation of the stone in the direction of the sedimentary planes.

Imprints are found on the face of each successive stratum; and on some of the layers, not only the tracks of animals that have walked over the clay when soft, are distinctly observable, but the surface often presents a blistered or warty appearance, being covered either with little hemispherical eminences or depressions, which an accurate investigation of the phenomenon has proved to have been produced by showers of rain. On the slabs of sandstone, the forms of the rain-drops and of the foot-prints appear in relief, being casts in the soft mud upon which the original impressions were made; while on the clay, corresponding depressions are apparent.*

The foot-prints on these strata are of several kinds; some appear to have been produced by small

* The impressions of rain-drops on stone were first noticed, and their origin explained, by Mr. Cunningham. *Geol. Proc.* Vol. III. p. 99.

reptiles and crustaceans; but the principal imprints are identical with those which have been observed in Saxony, and are referable to some large quadruped, in which the fore-feet were of a much smaller size than the hind-feet. From a supposed resemblance of the imprints to those of a human hand, Professor Kaup proposed the name of *Chirotherium*, to designate the unknown animal which had left these "footsteps on the sands of Time."* But since Professor Owen's discovery, that the bones and teeth of the reptiles found imbedded in similar strata in Warwickshire, belong to gigantic Batrachians, and the fore and hind feet of the frog-tribe are often as dissimilar in size as the impressions of the *Chirotherium*, it has been suggested, with much probability, that the foot-prints in question may be those of Labyrinthodonts; but until the form of the feet of these extinct Batrachians can be ascertained, this inference must be regarded as conjectural.†

ORNITHICHNITES (*Fossil foot-prints of Birds.*) *Lign.* 150, 151. (*Bd.* pl. 26.).—In certain localities of the New Red sandstone in the valley of the Connecticut, numerous tridactyle markings had been occasionally observed on the surfaces of the

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* *Bd.* I. pp. 259—266, contains a short but graphic account of these Ichnolithes; illustrated by admirable figures, in *Bd.* II. pl. 26.

† The restored figure of a Labyrinthodon (*Ly.* II. p. 90.), walking on sand, and leaving foot-marks, is a mere fanciful representation.

slabs of stone when split asunder, in like manner as the ripple-marks appear on the successive layers of sandstone in Tilgate Forest. Some remarkable distinct impressions of this kind at Turner's Falls (Massachusetts), happening to attract the attention of Dr. James Deane, of Greenfield, that sagacious observer was struck with their resemblance to the foot-marks left on the mud-banks of the adjacent river, by the aquatic birds which had recently frequented the spot. The conviction that the imprints on the stone, were referable to a similar origin with those on the mud, was so strongly impressed on his mind, that he immediately collected a series of specimens, and communicated his discovery and opinion to Professor G. Hitchcock, who followed up the inquiry with a zeal and success that have led to the most interesting results. No reasonable doubt now exists that the imprints in question have been produced by the tracks of bipeds, impressed on the stone when in a soft state. The announcement of this extraordinary phenomenon was first made by Professor Hitchcock, in the American Journal of Science (January, 1836); and that eminent geologist has subsequently published full descriptions of the different species of imprints which he has detected, with excellent lithographs, in his splendid work on the Geology of Massachusetts.*

* See also Prof. Hitchcock's "Elementary Geology," p. 150.

Three highly interesting specimens of the Ornithichnites of North America, collected and developed by Dr. James Deane, have been lately added to the collection of organic remains in the British Museum. They exhibit several varieties of the foot-prints, and are in a very fine state of preservation. The surface of the largest slab is eight feet by six, and bears upwards of seventy distinct impressions, disposed in several tracks, as shown in the *Lignograph* 151.

I subjoin an extract from Dr. Deane's description of these slabs, and a representation of one of the small foot-prints, of the natural size, on a block of the stone, with the surface sprinkled with hemispherical markings produced by drops of rain.* (*Lign.* 150.)

"It is rare to find a stratum containing these foot-prints exactly as they were impressed by the animals; for they are usually more or less distorted and obliterated by the soft nature of the mud, the coarseness of the materials, and other circumstances, which have partially defaced them; so that although the general form of the foot may be apparent, the minute traces of its appendages are almost invariably lost. In general, distinct evidence of the peculiar phalangeal structure of the toes of birds is wanting, and each toe appears to be formed of a single joint, without the terminal claw. But a few specimens have been discovered in which the true characters of the foot are clearly developed, with its rows of joints, and its claws, and integuments. So far as my observations extend, the sharpest impressions are on the shales of the finest

* From the American Journal of Science, Vol. XLVI. p. 73, December, 1843.

texture, with a smooth glossy surface, such as would retain the impressions of rain-drops (see *Lign.* 150.). The layers of

LIGN. 150. FOOT-PRINT OF A BIRD, AND IMPRESSIONS OF RAIN-DROPS, on Sandstone (*nat.*). *New Red Formation.* Massachusetts.

(*By Dr. James Deane, of Greenfield.*)

stone do not often present this kind of surface; but recently it has been my good fortune to discover a stratum containing, in all, more than one hundred most beautiful impressions of the feet of four or five varieties of birds; the whole surface having also been pitted by a shower of rain. The impression of a medallion is not more sharp and clear than are most of these imprints; and I would suggest that their remarkable preservation may probably be ascribed to the circumstance that the entire surface of the stratum was incrusted with a layer of micaceous sandstone, and which adhered so firmly, that it could not be removed without the laborious and skilful application of the chisel. The appearance of this glossy layer, which is of a grey colour, while the slab is of a dark red, seems to indicate that it was washed or blown over the latter, while in a state of loose sand; thus filling up the foot-prints and rain-drops, and preserving them unchanged in the smallest particular; the form of the nails or claws, and joints, and the deep impressions of the distal extremity of the tarso-metatarsal, or shank-bone, being exquisitely displayed. The great slab (*Lign.* 151.), which is about six by eight feet in dimensions, and two inches in thickness, contains above seventy-five impressions. There are five rows of the species called by Professor Hitchcock, *Ornithichnites fulicoides*,* of five and six foot-marks each; three rows of the medium size, of four imprints each; one row of the small size of fourteen consecutive imprints; besides several others, ranging from two to six impressions each. It is worthy of remark, that of these numerous foot-prints, with but one or two exceptions, two or more nowhere occur on the same spot."

The direction and disposition of these foot-prints on the large slab are shown in *Lign.* 151; and lines are drawn from one imprint to another in the consecutive series, to render the illustration more intelligible.

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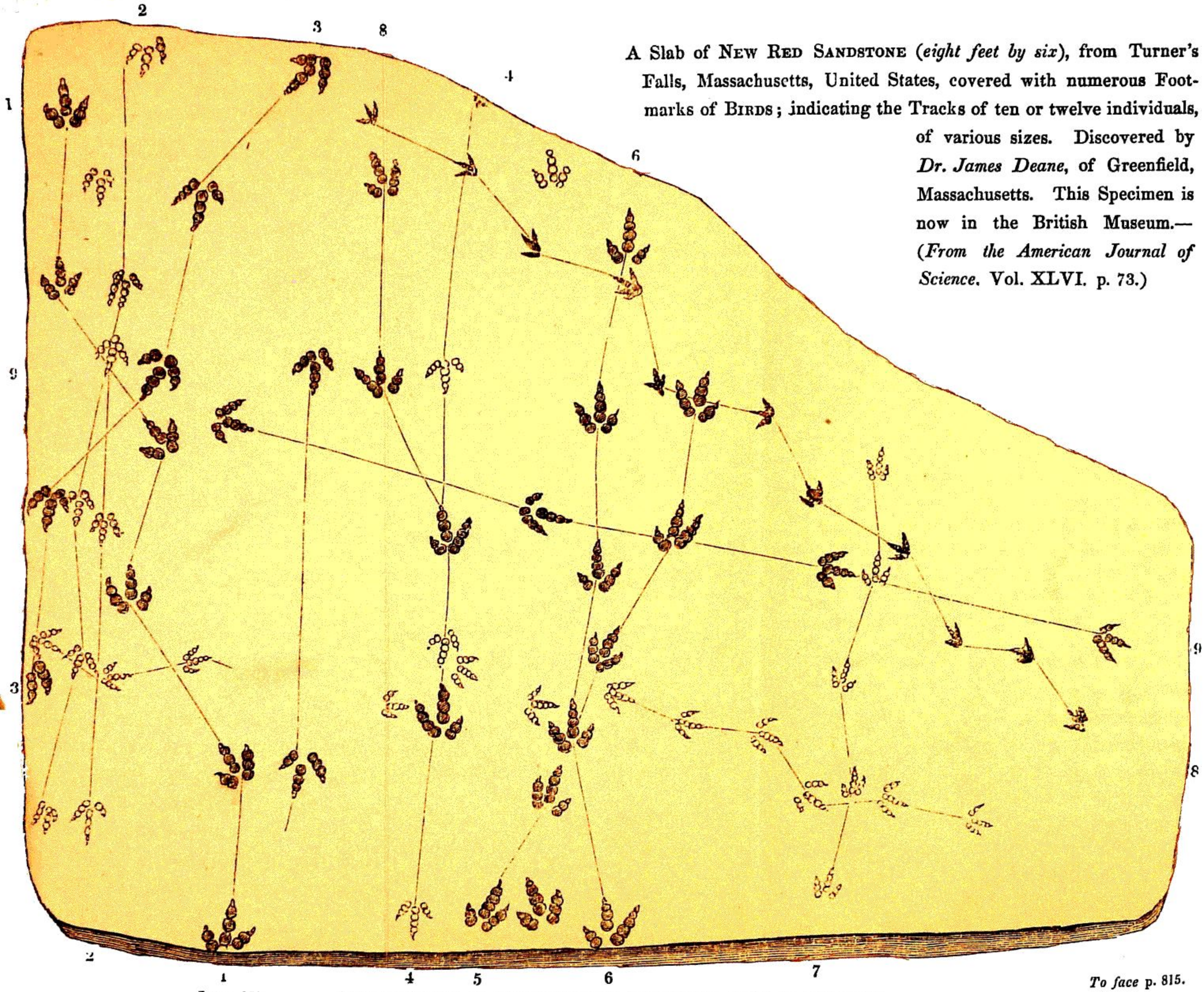
* *O. fulicoides*, so named from the resemblance to the foot-prints made by the recent Cinereous Coot (*Fulica Americana.*). See Trans. American Geologists, p. 259, 1 vol. 8vo. Boston, 1843.

A Slab of New Red Sandstone (*eight feet by six*), from Turner's Falls, Massachusetts, United States, covered with numerous Footmarks of Birds; indicating the Tracks of ten or twelve individuals, of various sizes. Discovered by *Dr. James Deane*, of Greenfield, Massachusetts. This Specimen is now in the British Museum.—(*From the American Journal of Science*. Vol. XLVI. p. 73.)




Lign. 151. Ornithichnites; or, Imprints of the Footsteps of Birds on Sandstone.

To face p. 815.

The principal tracks on this slab are as follow; viz.—

Fig. 1 to 1, directed from below upwards, is a track consisting of six large footsteps.
2 to 2, from above downwards; a track of four foot-prints, disposed almost in a right line, and very far apart.
3 to 3, a track of five foot-prints, from above downwards, of a large, heavy bird, like fig. 1.
4 to 4, from above, downwards, four foot-prints like fig. 2, disposed in a nearly straight track, and far apart.
5, a track of five heavy foot-prints, directed obliquely upwards.
6 to 6, five foot-prints of a large bird, in a track from below upwards.
7, a series of five delicate foot-prints.
8 to 8, a track of eleven very small foot-prints, disposed in zig-zag, and extending obliquely from the right extremity to the upper edge of the slab.
9 to 9, a track of four large and distant foot-prints, passing obliquely across the stone from left to right.

This description will suffice to give the reader a general idea of the nature of these extraordinary impressions. A few shapeless fragments of bones are the only vestiges of the skeletons of any animals, with the exception of fishes, that have been found in the strata which have furnished the slabs of Ornithichnites; but some Coprolites have been discovered, which, from a chemical analysis, Dr. Deane informs me, seem to have belonged to omnivorous birds. The enormous size of some of the foot-marks are calculated to excite great surprise. I have in my possession (through the kindness of Dr. Deane) imprints that prove the size of the foot to have been fifteen inches in length, and ten inches in width, exclusive of the hind claw, which is two inches long. The foot-prints of this bird when in a consecutive series of five or six, are from four to six feet apart; which, of course, must have been the length of the stride of the bird; the longest stride was probably made by the animal when running; the shortest, when walking at a moderate pace. These footsteps indicate proportions so far exceeding those of all known living bipeds,—for the foot of the African ostrich is but ten inches long,—that the geologist may be pardoned for having hesitated to adopt the opinions of the American savans, in the absence of any relics of the osseous structure of the supposed Birds; although sanctioned by the high authority of Dr. Buckland, who, from the first, concurred in the views of Professor Hitchcock (*Bd.* II. p. 39.). But much scepticism prevailed among our geologists concerning the true nature of these impressions; and I candidly confess my incredulity, until a series of specimens sent to me by Dr. Deane, (and which was laid before the Geological Society of London), accompanied with a graphic description of the circumstances connected with their position in the strata, brought conviction to my mind. Professor Hitchcock is of opinion that upwards of thirty species of foot-prints may be distinguished.

DINORNIS *(fearfully great bird.)*.—An insuperable obstacle to the adoption of the views of the American philosophers, with some distinguished geologists, was the enormous size of the largest foot-prints; but this objection has been removed by a discovery as unexpected and marvellous as that of the Ornithichnites of Connecticut; namely, of the skeletons of several species of unknown birds, with feet equal in magnitude to the largest foot-prints, in the alluvial deposits of the existing streams and rivers of the north island of New Zealand. These bones have been described in a highly interesting memoir (published in the Transactions of the Zoological Society) by Professor Owen, who refers them to a tridactyle Struthious bird, one-third larger than the African ostrich, and resembling the Apteryx (see *Wond.* p. 118.), in the proportions of the tibia to the metatarsus; probably also in the rudimental state of the wings. This bird Professor Owen has named *Dinornis Novæ Zelandiæ;* and states that its shank-bone is large enough to have sustained three toes, equivalent to produce impressions equalling in size those of the largest American Ornithichnites. The author further observes, that it seems most reasonable to conclude that the Ornithichnites are the impressions of the feet of birds, which had the same low grade of organization as the *Apteryx* and the *Dinornis;* and that these last may be regarded as the remnants of an apterous *(wingless)* race of birds, which seems to have flourished at the epoch of the *New Red* sandstone of Connecticut and Massachusetts.* These bones were sent to England by Rev. W. Williams, who collected them from the alluvial mud at Poverty Bay;† among these remains are a tibia (large bone

* American Journal of Science, Vol. XLV. p. 187.

† It may be questioned whether these bones are not washed by the streams out of an ancient alluvial deposit, and transported into the river; for my son, Mr. Walter

of the leg) 28½ inches long; a femur, or thigh-bone, 14 inches long, and 7½ in circumference; and parts of skeletons belonging to thirty individuals. The natives believe that similar birds are still in existence; but although from the state of the bones it is probable that their extinction, like that of the Dodo, is comparatively of recent date (see *Wond.* p. 116.), no evidence has at present been obtained to prove that they have ever been contemporary with the aboriginal inhabitants of New Zealand.

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ON COLLECTING THE FOSSIL REMAINS OF BIRDS.—Notwithstanding the extreme rarity of fossils of this class, the student should not be discouraged in his search for the remains of Birds in the secondary rocks. That far more instructive specimens than any that have fallen under my observation, may be discovered in the Wealden strata by diligent research, there can be no reasonable doubt. It is also very probable that the Stonesfield slate, which abounds in remains of terrestrial plants and animals, will be found to contain Ornitholites. It is important for the collector to bear in mind, that when only a fragment of the shaft of a bone remains imbedded in the stone, if the imprint of the other portions be preserved, he may obtain a knowledge of the form of the extremities; in the same manner

Mantell, of Wellington, New Zealand, informs me that he has obtained bones that were dug up by a native in sinking a potatoe-pit.

as the external markings of the surface of a shell may be ascertained, when the shell itself is lost or destroyed, and a smooth, stony cast of the internal cavity only is left (see p. 443.). The same remark will apply to the bones of reptiles and other animals; for example, the perfect femur of a young Iguanodon may be imbedded in a block of limestone; but when exposed by breaking the stone, a portion of the shaft may alone remain attached, and both extremities be shattered to pieces by the concussion of the blow; yet, if the impression remains, the entire form of the original may be determined. Had the shank-bone of the *Palæornis, Lign.* 149, been found imbedded in the rock, notwithstanding the loss of both extremities, the perfect form might have been determined by a cast taken from the cavities left in the stone; and thus more certain data have been obtained of the nature of the original.

The *foot-prints*, not only of birds, but of reptiles, and other animals, should be diligently sought for on the surfaces of laminated strata of sand and clay, and especially where the presence of ripple-marks, and the impressions of rain-drops, indicate that the beds were deposited in shallow water. The sandstones around Horsham (in Sussex), and particularly at Stammerham, are deeply rippled (see *Geol. S. E.* p. 213.); and it is therefore probable that the foot-prints of some of the Wealden reptiles, and perhaps of the *Palæornis*, will, sooner or later, be discovered.

# CHAPTER XX.

## FOSSIL MAMMALIA.

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THE remains of MAMMALIA that have been discovered in a fossil state, include an immense number of species, and furnish examples of almost every living genus, and of numerous genera, and even orders, of which no existing species are known. Yet amidst the vast accumulations of the skeletons of the higher orders of vertebrata contained in the superficial drift, and in tertiary deposits, belonging to species which have successively appeared on the surface of our planet, flourished for indefinite periods of time, and then become annihilated, no vestiges of MAN, or of his works, have been detected. Human skeletons naturally imbedded, have hitherto only been observed in the silt of modern alluvial plains, and in peat-bogs (*Wond.* p. 47.), and in conglomerates of recent date, which are still in the progress of formation on the sea-shores; particularly of those whose waters are loaded with the detritus of shells and corals, and discharge the calcareous matter on the margins of creeks and bays, or in the shallows along the coast (see *Wond.* pp. 69 and 71.*).

The geological distribution of fossil mammalia,—the occurrence of the entire carcases of extinct species of the Elephant and Rhinoceros in blocks of ice (*Wond.* p. 139.),—of recent species in the superficial alluvial clay and silt (*Wond.* p. 46.),—of recent, with extinct forms in the Drift, or ancient alluvium (*Wond.* p. 145.),—of the gradual preponderance of unknown species and genera, in proportion as we advance to the most ancient Tertiary strata (*Wond.* p. 239.),—the sudden disappearance of all vestiges of the entire Class of Mammalia, with the last bed of the Eocene deposits,—with the solitary exception of a few minute jaws in one bed of the Oolite (*Wond.* p. 447.), the sole record of the existence of any of the highest types of animal organization throughout the vast periods embraced by the secondary formations,—all these phenomena are so fully treated of in other works (*Bd.* I. pp. 81—96. *Ly.* I. pp. 305—316. *Wond.* pp. 125—182.), that I need not dwell upon the subject. Neither is it desirable to enter at large upon this department of Palæontology, for it were vain to attempt the elucidation of the anatomical characters of but one

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* The human foot-prints (*Wond.* p. 76.) on limestone, on the banks of the Mississippi, have been shown by Dr. Owen, of New Harmony, to be artificial.—*Amer. Journ. of Science*, Vol. XLIII. p. 14.

extinct species of Mammalia, without giving details of structure, that would extend over a greater space than can be afforded in these volumes; and which, indeed, could only be successfully demonstrated in a work expressly devoted to the subject. Our remarks on the Fossil Mammalia will, therefore, be very general, comprising a brief summary of modern discoveries, with suggestions for the identification and collection of some of the most interesting or prevalent remains.

The subjects will be considered under the following general heads:—

I. CETACEANS; or animals of the *Whale tribes.*

II. RUMINANTS; including the *Giraffe, Deer, Oxen,* &c.

III. PACHYDERMATA; comprising the *Proboscideans,* as the Elephant; the ordinary *Pachyderms,* as the Rhinoceros; and the *Solipedes,* or Horses.

IV. EDENTATA; animals without teeth, or with only molar teeth, as the *Sloth, Ant-eater, Megatherium,* &c.

V. RODENTS, or GNAWERS; as the *Hare, Beaver,* &c.

VI. MARSUPIALIA; animals with an abdominal pouch, as the *Kangaroo.*

VII. CARNIVORA; including the *Bats,* and the carnivorous tribes in general.

VIII. QUADRUMANA; *Apes* and *Monkeys.*

I. FOSSIL CETACEA.*—The *Cetaceans*, although generally termed fishes, are as perfect air-breathing, vertebrated animals, as the terrestrial mammalia, and, like them, give suck to their young. Instead of fore-feet or arms, they have a pair of fins, or paddles, but are destitute of hinder extremities, the place of the latter organs being supplied by a powerful cartilaginous horizontal fin, appended to the tail. The Cetaceans, therefore, differ in this respect from the fossil marine reptiles, the Ichthyosaurus and Plesiosaurus (see p. 708.), which have two pairs of paddles. This order, as is well known, comprises the most colossal forms of animal existence,—the Whales. Some are herbivorous, others carnivorous; many have powerful teeth; others are edentulous, the jaw being covered with a series of plates of the substance familiarly known by the name of *whalebone*.

The fossil remains of Cetaceans have, for the most part, been observed in alluvial silt, and beds of drift, in valleys still traversed by rivers; but many examples have been discovered in elevated sea-beaches, proving that, although, geologically speaking, these beds are of modern origin, yet great changes in the relative level of the land and sea must have taken place, since these remains were imbedded. Thus, on the banks of the river Forth,

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* *Cetacea.* An order of aquatic mammalia, comprising the Whales, Dugongs, Porpoises, Dolphins.

near Alloa, in Scotland, the skeleton of a Whale (*Balænoptera*) seventy-two feet long, was discovered imbedded in clay, twenty feet above the highest tide.* Baron Cuvier mentions the discovery of bones of a *Lamantin* at Angers; of a Dolphin, and Rorqual, in Lombardy; and of a Grampus, in the pliocene of the Sub-Appenines. A few detached vertebræ of Whales have been found in England, but in situations which throw some doubt as to whether the specimens may not have been imbedded by human agency.

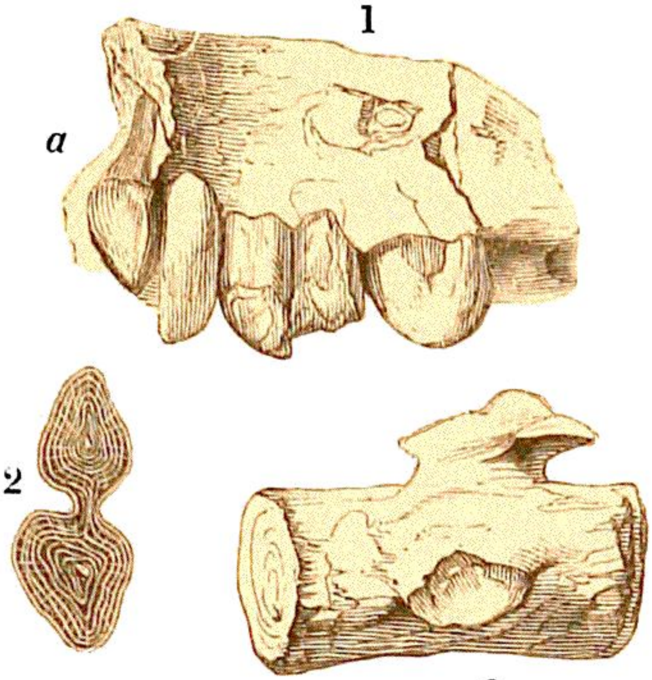
BRIGHTON FOSSIL WHALE.—An interesting discovery of a fragment of the jaw of a Whale, undoubtedly coeval with the extinct Mammoth (*Elephas primigenius*), was made in 1828 in the Cliff, east of Brighton, under the following circumstances. On the face of the Cliff, in the ancient shingle which lies immediately upon the chalk, and is surmounted by beds of calcareous rubble, containing bones and teeth of Elephants, to the height of one hundred and twenty feet, some fishermen had observed a huge bone, that had been laid bare by an unusually high tide, and now projected two or three feet beyond the face of the Cliff. Unable to remove it, they broke off the extremity, a fragment of which was sent to me. Upon repairing to the spot a few days afterwards, I found that the fishermen had renewed their attack, and demolished a considerable portion

* Dr. Fleming's "British Animals," p. 39.

of the bone in ineffectual attempts to dislodge it from its bed; and had desisted only from the apprehension of being buried beneath the overhanging cliff, which is composed of very loosely aggregated materials. Unfortunately, the bone extended directly into the cliff; and it required several hours of labour, not unattended with danger, before an excavation was made sufficiently large to expose the entire specimen. It proved to be the anterior *nine feet* of the left branch of the lower jaw of a whale-bone Whale (*Balæna mysticetus*). It was of a light fawn colour externally, but the internal coarse osseous structure was delicately white; it was extremely brittle, and upon attempting to move it, broke into a thousand pieces. Time would not permit of the application of a coating of plaster of Paris, for ere we had completed our task, the tide was rapidly approaching, or this interesting relic might have been extracted entire. This fragment of jaw, before it was mutilated by the fishermen, was about twelve feet long, and thirty-six inches in circumference at the largest extremity. It must have belonged to a Whale from sixty to seventy feet in length (see *Lign.* 160.).

In the fluviatile silt of the valley of the Ouse, near Lewes (*Wond.* p. 45.), the skull of a Porpess, and a portion of the cranium, with the socket of the long tusk, or tooth, of a Narwhal (*Monodon monoceros*), were found twelve feet beneath the surface of the soil.

The bones of an herbivorous Cetacean, the *Manatus*, a genus now peculiar to the torrid zone, have been found in the eocene strata in various parts of France, associated with those of the Palæotheria, and other extinct mammalia of the Paris basin.




LIGN. 152. PORTION OF THE JAW, WITH TEETH, AND A VERTEBRA, OF ZEUGLODON CETOIDES. *Tert.* Alabama.

Fig. 1.—Portion of the upper jaw, with three teeth: $\frac{1}{8}$ *nat.*
*a.* Denotes the exposed fang of a tooth.
2.—Transverse section of the crown of a tooth: $\frac{1}{4}$ *nat.*; showing the deep constriction in the middle.
3.—A caudal vertebra: $\frac{1}{12}$ *nat.*

ZEUGLODON CETOIDES. *Lign.* 152. (*Geol. Trans.* Vol. VI. pl. 7, 8.).—The remains of an extraordinary fossil Cetacean, of an extinct genus, were first made known by Dr. Harlan, of Philadelphia,* who

* Beautiful figures of the teeth, vertebræ, &c., of the natural size, are given by Dr. Harlan, in his interesting

obtained a considerable portion of the jaws with teeth, vertebræ, and other bones, of an animal of enormous size, from the State of Alabama, United States. These relics were discovered in tertiary limestone, associated with a marine shelly conglomerate, from a cliff near the bed of the river Owachita. When first observed, the bones extended along the face of the rock, with intervals between them, to the extent of one hundred feet, and the animal to which they belonged must have exceeded seventy feet in length. Dr. Harlan ascribed these bones to an unknown reptile, which he called Basilosaurus (*king of the lizards*); but a more correct investigation, by Professor Owen, proved their cetaceous character; and the peculiar form of the teeth suggested the name of *Zeuglodon.**

The teeth are of two kinds, some having but one fang, and others two, implanted in separate sockets, and placed obliquely in the jaw; they are of a compressed, conical form, with an obtuse apex, the crown being deeply conjugate, or contracted in the middle, as shown in the transverse section, *Lign.* 152, fig. 2. They are devoid of enamel, but the dentine is coated with cement, and their structure

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work, *Medical and Physical Researches*, 1 vol. 8vo. Philadelphia.

* Zeuglodon, *yoked-tooth;* so named from the contraction in the middle, presenting the appearance of two teeth yoked together. See Prof. Owen's Memoir, *Geol. Trans.* Vol. VI.

is decidedly mammiferous; and a microscopical examination, Professor Owen states, incontestably proves their cetaceous character. The longitudinal diameter of the middle tooth is three inches.

The vertebræ resemble those of the large cetacean, known by the name of *Hyperoodon;* a caudal vertebra is figured *Lign.* 152, fig. 3. The original animal was related to the Dugong and Cacholot, and appears to have held an intermediate place between the latter and the herbivorous species.

II. FOSSIL RUMINANTS.—The fossil bones of animals of this order are very numerous in the alluvial deposits, in caves, and in Drift, in almost every part of the world. They are generally associated with the remains of the next group. The skulls of Oxen, and horns and bones of the Bison and Auroch, have been found in North Cliff, Yorkshire, at Walton in Essex, and other parts of England. The fossil oxen appear to have been one-third larger than the recent species; and the horns are relatively more massive than in the domestic race; some of the horns measure four feet across, at the widest expansion. In the immense accumulations of large mammalia in the Drift of the Sub-Himalaya mountains, called the Sevalik range, numerous remains of oxen occur. The teeth of one species is often found in the Elephant bed at Brighton.

Of the Deer family the relics of several kinds have been discovered in Drift and Caverns. The cave of Kirkdale alone contained the remains of three species.* The bones of a species that cannot be distinguished from the common Red Deer, are found in the modern shell marls of Scotland, associated with remains of oxen, horse, boar, dog, wolf, and beaver. The ossiferous caverns, which contain bones of Carnivora, also yield those of Deer; as the caves of Kirkdale and Banwell, &c. in England, and the celebrated caverns of Muggendorf, on the Continent. A species of Musk-deer has been found at Eppleshelm; and bones of deer are associated with those of the Dinotherium, in Rhenish Hesse, in Drift. The teeth and a lower jaw, with other bones of a species of deer, were obtained from the Brighton Elephant bed (*Wond.* p. 102.).

The most celebrated fossil animal of this family is the Gigantic Stag, or Elk, as it is commonly called, of Ireland (see *Wond.* p. 120.); whose bones and antlers are found in immense quantities in superficial marl, in Ireland, in the Isle of Man, and occasionally in England. A skeleton, almost entire, discovered in the Isle of Man, in marl abounding in fresh-water shells, at the depth of twenty feet, is six feet high, nine feet long, and nine and a half feet in height, to the top of the right horn. Some

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* Reliquiæ Diluvianæ; or, Observations on the Organic Remains found in Caves, Fissures, and Gravel; by the Rev. W. Buckland, D.D., &c. 1 vol. 4to. 1823. pl. 8 and 9.

antlers are so large, that the interspace from one point to the other exceeds twelve feet.*

The GIRAFFE, the tallest of known quadrupeds, and now restricted to the deserts of Africa, was once a native of Europe and Asia; for fossil bones of a species of this remarkable ruminant have been found at Issoudun, in France, and in the Sevalik mountains, with several varieties of Elk and Deer.

Of the CAMEL, the only ruminant with incisor teeth in the upper jaw, a gigantic species has been discovered by Dr. Falconer and Captain Cautley, in the Drift of the Sevalik mountains.

In this category we must notice another most interesting discovery of the indefatigable and eminent naturalists above mentioned, namely, the *Sivatherium* (see *Wond.* p. 152.), an extinct animal, which forms, as it were, a link between the ruminants and the large pachydermata. The skull has four persistent horns, and was furnished with a nasal proboscis. The living creature must have resembled an immense Antelope or Gnu, with a short and thick head, and an elevated cranium, crested with two pairs of horns. A splendid specimen of the skull of the *Sivatherium* has recently been placed in the palæontological collection of the British Museum, by Dr. Falconer.

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* A good figure of the skeleton of the fossil Irish Elk, is given in the Penny Cyclopædia, Vol. VIII. p. 364.

III. PACHYDERMATA.—The fossil remains of this order of mammalia are most abundant, and belong to numerous species, comprising many extinct genera of a highly interesting character. They are divided into three tribes, or groups; namely, the *Proboscideans*, so named from their possessing a prehensile flexible trunk or proboscis, which includes the Elephant, Mastodon, and Dinotherium; secondly, the ordinary Pachydermata, as the Hippopotamus, Rhinoceros, Tapir, and the Cuvierian pachyderms; and thirdly, the *Solipedes*, or Horses, &c.

FOSSIL ELEPHANTS AND MASTODONS. *Wond.* pp. 138—152.—The bones, teeth, and tusks of Elephants, equal in magnitude, and distinct from the existing African and Asiatic species, are scattered throughout the superficial accumulations of Drift and alluvial detritus throughout Europe. I must refer to *Wond.* p. 138, for a brief account of these remains.

The fossil bones and teeth of these gigantic animals are so abundant, that examples may be found in all the provincial, and in most private collections; and the British Museum possesses an unrivalled series of specimens of both groups of these colossal herbivorous mammalia, namely, the Elephants properly so called, and the Mastodons. It contains an invaluable series of specimens from the Sivalik hills, presented by Captain Cautley and Dr. Falconer; and which proves that the Mastodon and the Elephant can scarcely be regarded as generically distinct; for the dental organs present every modification of structure, from that of the mastoid tubercles of the tooth of the Mastodon, to the vertical laminæ of cement, enamel, and dentine of the Elephant. The Museum also possesses the entire skeleton of the Mastodon, lately exhibited by Mr. Koch, as well as the fine suite of jaws and teeth, obtained by the same indefatigable collector. This collection demonstrates that all the bones and teeth, apparently of several species, and, as some have supposed, of distinct genera, belong but to the one grand Mastodon—the *M. giganteus* of Baron Cuvier; it also clearly proves that the young Mastodon had a pair of tusks, placed horizontally in the lower jaw; and that but one of these tusks became developed in the adult, and that only in the male.*

It is therefore unnecessary to enlarge upon this subject, for an inspection of a few specimens will afford the student a clearer insight into the structure of the skeletons and teeth of these animals than any description. The form of the teeth, and the disposition of the dental elements are illustrated in *Wond.* pp. 142—146, and *Ly.* pp. 313, 314.

DINOTHERIUM. *Wond.* p. 162. *Bd.* I. p. 135. pl. 2.—At Epplesheim, forty-miles north-east of Darmstadt, in beds of sand and marl of the median

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* This remarkable circumstance, in the infancy of palæontological science, gave rise to a very venial error; it was made to constitute the character of a new genus, to which the name *Tetracaulodon* was applied.

Tertiary formations, the jaws, teeth, skull, and other remains of this most gigantic of terrestrial mammalians have been discovered, and are preserved in the museum at Darmstadt. The length of the largest species is estimated at eighteen feet. The teeth had previously been found in France, Bavaria, and Austria; and from their close analogy to those of the Tapir, were described by Baron Cuvier as belonging to an extinct colossal animal of that genus.* But subsequent discoveries have shown that the *Dinotherium* was a proboscideal animal, allied to the Mastodon; and had two large curved tusks directed downwards in the anterior extremity of the lower jaw.†

CUVIERIAN PACHYDERMATA. *Wond.* p. 241. *Bd.* I. p. 81.—A large proportion of the numerous bones and teeth which are found in the Tertiary gypseous deposits at Montmartre, near Paris, are referable to the several extinct genera of Pachydermata, which the genius of Cuvier first made known. The *Palæotheria* and *Anoplotheria*, must be familiar to the intelligent reader, for the restored

* My cabinet contains (through the kindness of the widow of the late Mr. Bakewell) the first specimen of a tooth of the *Dinotherium* discovered at Grenoble, in France. It was formerly in the possession of Faujas St. Fond, and has attached to it a ticket descriptive of its locality, by that celebrated naturalist.

† There are good models of the Darmstadt specimens in the British Museum.

outlines of several species are appended to almost every work that treats of the ancient inhabitants of our globe. The details of their anatomical characters are given at length in *Oss. Foss.* Tom. III.; illustrated with numerous plates.

The *Palæotheria* resembled the Tapirs in their head, and short proboscis, while their molar teeth approached those of the Rhinoceros; and their feet were divided into three toes, instead of four, as in the Tapirs. Upwards of eleven species have been discovered, varying from the size of the Rhinoceros to that of the Hog. Their remains are extensively diffused in the Tertiary strata in various parts of France.

The LOPHIODON *(crested-tooth)*, a genus distinguished from the former by the characters of the teeth, which more nearly resemble those of the Tapirs, comprehends twelve species, all found in the fresh-water Tertiary marls of France. A canine tooth of a species of *Lophiodon* was found in the London Clay, at the depth of 115 feet, in sinking a well on Sydenham Common, near the railway.*

The ANOPLOTHERIA have two characters not observed in any other animal, namely, feet with but *two* toes, the metacarpal and metatarsal bones of which do not unite into a single piece, as in the ruminants; and teeth placed in a continued series without any interval between them; man alone has the teeth

* See Mr. Douglas Allport's highly interesting work, "HISTORY OF CAMBERWELL," p. 17.

arranged in the same manner. There are also sub-genera, as for example, *Xiphodon* and *Dichobune*, characterised by peculiarities of dental and osteological structure; and *Anthracotherium* (so named from two species having been found in a bed of Anthracite or Lignite, near Savone), a genus intermediate between the Palæotheria and Hogs. The skeletons of these remarkable animals are imbedded with the remains of carnivora, marsupialia, bats, birds, crocodiles, tortoises, and fishes.

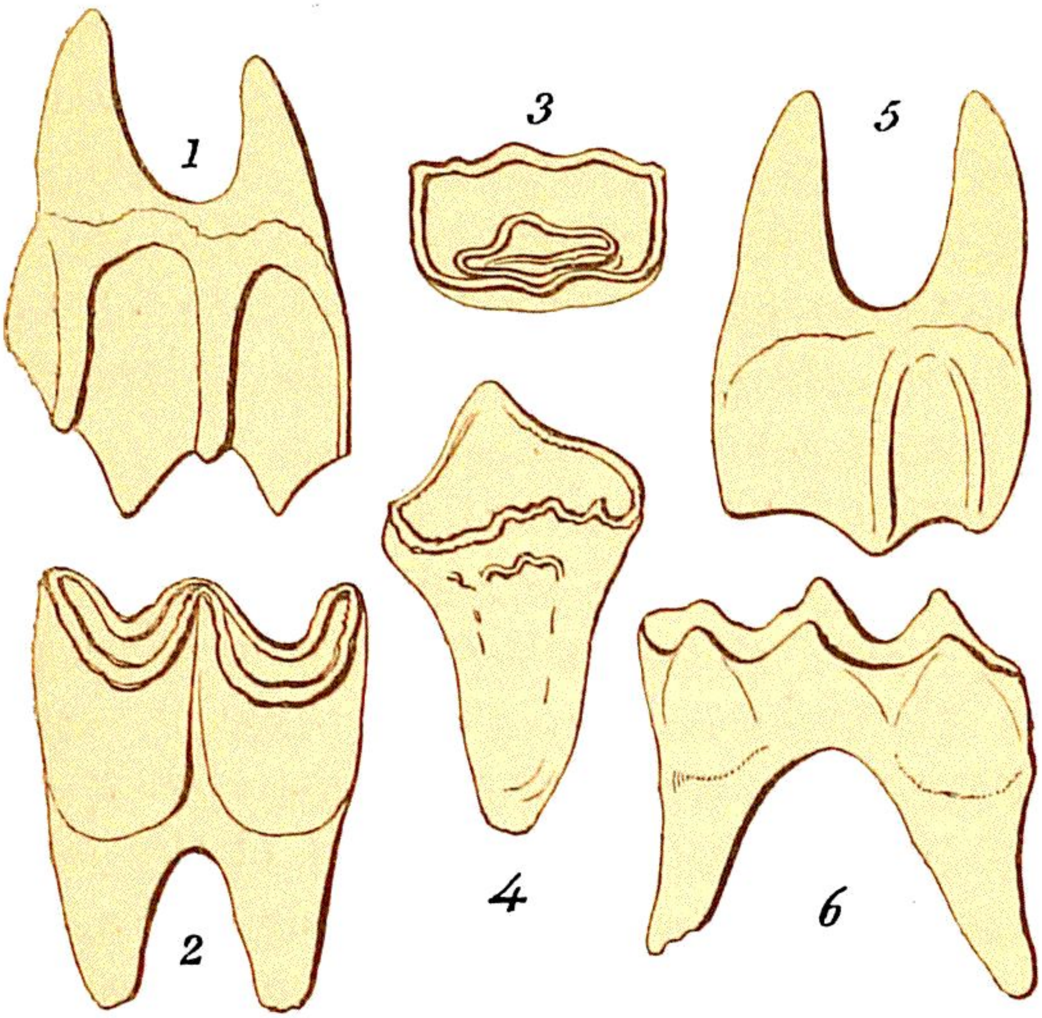
In England, no remains of the extinct Pachydermata of the Paris Tertiary strata were discovered till a few years since, and they are still exceedingly rare. There have been found in the fresh-water limestone at Binstead, near Ryde, and at Seafield, Isle of Wight, teeth and portions of the jaws of two species of Anoplotherium, four of Palæotherium, and one of *Chæropotamus*, an animal allied to the Hog tribe (*Geol. Trans.* Vol. VI. pl. 4.).

Two species of a new genus, intermediate between the Hog and the Hyrax, named by Professor Owen, *Hyracotherium*, have been discovered in the London Clay at Kyson, in Suffolk, and in the cliffs at Studd Hill, about a mile to the West of Herne Bay.* The latter specimen consists of a mutilated skull, about the size of that of a Hare, with the molar teeth perfect.

I subjoin figures of molar teeth of *Palæotherium* and *Anoplotherium* (*Lign.* 153.).

* Geol. Trans. Vol. VI. pl. 21. p. 203.

The other large fossil Pachyderms, belonging to the two existing genera of Rhinoceros and Hippo-




LIGN. 153. TEETH OF CUVIERIAN PACHYDERMATA. *Tert. Isle of Wight.*

Fig. 1.—Upper molar tooth (external surface) of PALÆOTHERIUM MAGNUM. *Binstead.*
2.—Lower molar of PALÆOTHERIUM MAGNUM.
3.—Grinding surface of first upper molar of ANOPLOTHERIUM SECUNDARIUM. *Binstead.*
4.—Inner side view of right upper canine of ANOPLOTHERIUM COMMUNE.
5.—Upper molar of ANOPLOTHERIUM COMMUNE. *Montmartre.*
6.—Lower molar of the same animal.

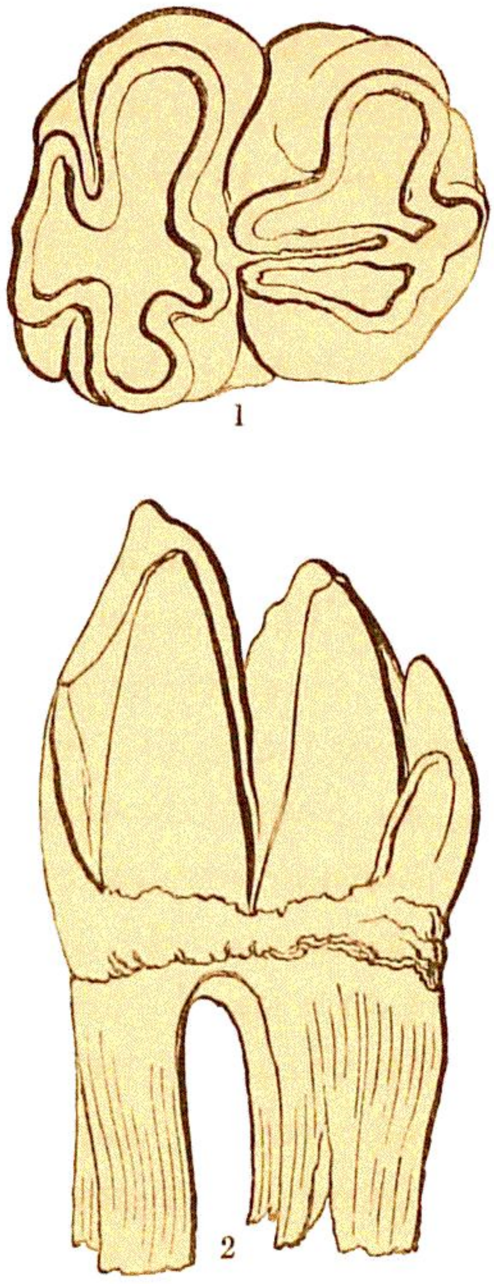
potamus, are found very extensively distributed in Drift, alluvial debris, and in the ossiferous breccia of caverns; and their remains are frequently dug up in the superficial marls, clays, gravel and sand of England. As the teeth of these animals will occasionally be met with by the collector, a brief explanation of their form and structure may be useful.

TEETH OF MAMMALIA.—The organization of the teeth in the herbivorous mammalia, essentially consists in the adaptation of the three elements of dental structure to the peculiar conditions required by the habits and economy of the different species. Thus, in the Elephant, Horse, &c., the dentine, cement, and enamel are disposed in vertical plates more or less inflected; the enamel and cement penetrating the body of the tooth, and embracing corresponding processes of dentine; an arrangement by which a grinding surface, composed of three substances of unequal densities is produced and maintained in every state of detrition.* But these teeth do not possess the symmetrical and complicated structure observable in those of many of the reptiles and fishes we have previously investigated. In the carnivorous mammalia, the enamel constitutes an external shell or case, investing the body of dentine, and presenting sharp cusps, or trenchant ridges, adapted for the laceration of flesh, as in the Tiger, or modified so as to form instruments for snapping and crushing bones, as in the teeth of the Hyena.

* Professor Owen.

In the common Mastodon, the crown of the tooth, when first emerged from the gum, presents a series of strong conical eminences (*Wond.* p. 146.), that become worn down by use; at first into disks (*Ly.* I. p. 121.), which, by further detrition, coalesce. The tooth of the Elephant, on the contrary, consists of vertical plates of dentine, with an immediate investment of enamel, over which there is an external layer of cement, that binds together the entire series of plates, often amounting to twenty or more; the horizontal surface produced by the detrition of such a structure, gives rise to the well-known grinding surface of the molars of the elephant. (*Wond.* p. 150 and 142. *Ly.* I. p. 313.). Detached plates of the teeth of Elephants, particularly of those which belong to the back part of the posterior grinder, and have not come into use, are puzzling to the inexperienced collector of fossil remains; and the first indication I obtained of the existence of the remains of fossil Elephants in Brighton Cliffs (*Wond.* p. 102.), was from a mass of this kind, dug up in sinking a well in Dorset Gardens, and sent to me as a "petrified cauliflower."

I subjoin, (*Lign.* 154, fig. 1.), a figure of the crown of a fossil molar tooth of a Hippopotamus, from Kent's Cavern, Devonshire; in this specimen the summits of the cusps are worn down by use; and another, fig. 2, representing a perfect molar, with the conical cusps of the crown entire, found in a bed of Drift, in Hertfordshire, by W. D. Saull, Esq.




LIGN. 154. FOSSIL MOLAR TEETH OF HIPPOPOTAMUS: $\frac{2}{3}$ *nat.*

Fig. 1.—Grinding surface of a molar tooth, with the cusps partially worn away. *Kent's Cavern, Devonshire.*

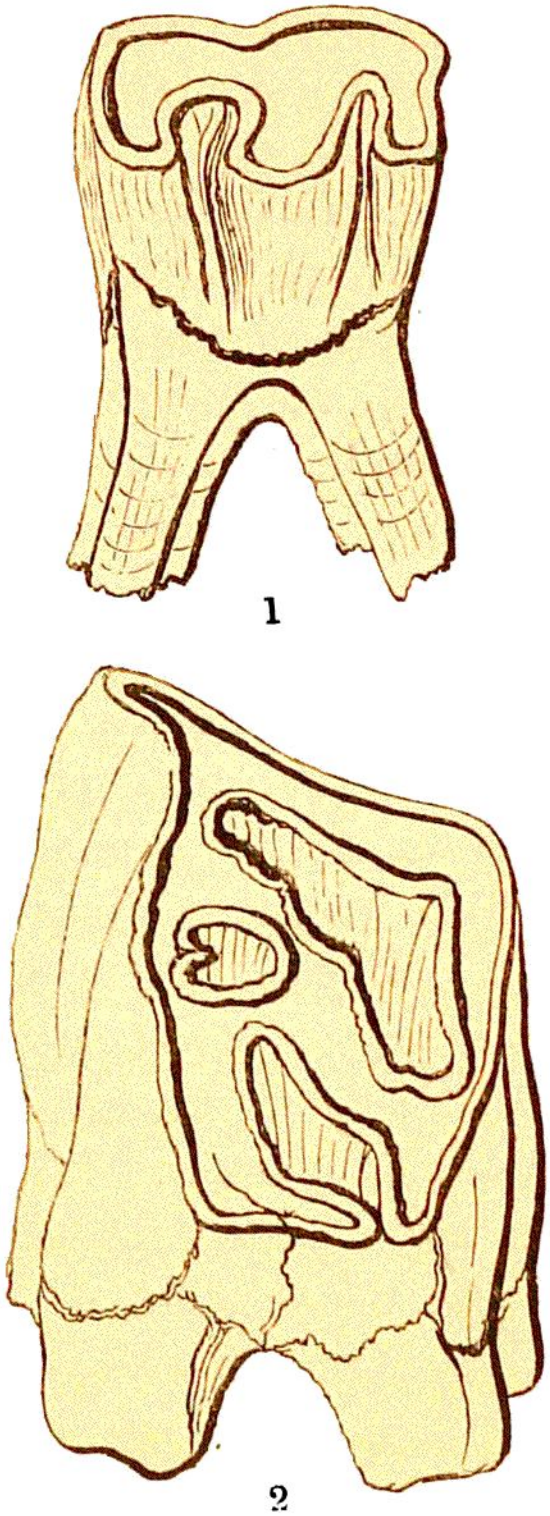
2.—Perfect molar tooth, seen laterally. From a bed of *Drift;* in Hertfordshire.

*(Collected by W. D. Saull, Esq.)*

The form of the worn surfaces of the molars of the Rhinoceros, is shown in two different stages in the fossil teeth represented *Lign.* 155. Mr. Lyell has given figures of the teeth of the Horse, Ox, Deer, &c. (*Ly.* I. p. 315.); but teeth of the recent species are so readily obtained, and so much more instructive, that I would recommend the student to procure teeth of the domestic herbivorous, carnivorous, and rodent animals, and preserve them in his cabinet as objects for comparison with the fossil mammalian teeth he may discover.

FOSSIL HORSE.—The bones and teeth of one or more species of this widely-distributed genus, are found in the alluvial drift, in osseous breccia, and in caverns, in numerous localities in Europe and Asia. The teeth and bones of horses are often met with, in the Elephant bed, in Brighton cliffs; they are referable to a small species, about the size of a Shetland pony. The blue alluvial clay, or silt, of our existing river valleys contains abundance of the remains of a horse not distinguishable from the recent.

In the Sevalik hills, collocated with the gigantic pachydermata, ruminants, and carnivora, the remains of two or more species of Horse have been discovered. One species is remarkably distinguished from any previously known, by the extreme length and slenderness of its legs, in which respect it must have closely resembled the Antelope, and not surpassed in size the common Deer.




**Lign 155. Fossil Molar Teeth of Rhinoceros:** $\frac{2}{3}$ *nat.*

**Fig. 1.—A molar tooth, much worn down by use; with the fangs nearly perfect.** ***In drifted gravel; Petteridge Common, Surrey.***

**2.—Large molar, very much worn by use; the fangs broken off.** ***Kent's Cavern, Devonshire.***

IV. FOSSIL EDENTATA.*—The remains of extinct colossal mammalia, related to the existing diminutive SLOTHS in the essential characters of their organization, but modified to suit the peculiar conditions in which they were placed, and the enormous increase in bulk of their colossal frames, are strewn all over the vast area of those alluvial plains of South America, called the PAMPAS (*Wond.* p. 154.). The deposits of these regions consist of—1. Beds of clay, sand, and limestone, containing marine shells and teeth of sharks; these are the lowermost strata. 2. Indurated marl. 3. Red clayey earth with calcareous concretions, in which the bones of colossal terrestrial mammalia are abundant. This vertical section demonstrates, that an extensive bay of salt-water was gradually encroached upon, and at length converted into a muddy estuary, by detritus brought down from the interior of the country, and in which carcases of land animals floated, and ultimately became engulphed in the silt. It is in these last deposits, which now form the immediate subsoil of the Pampas, that the teeth of the *Megatherium*, *Mylodon*, gigantic Armadillo, Mastodon, Horse, &c. have been found.†

The MEGATHERIUM (*Wond.* p. 153. *Bd.* p. 139, and pl. 5.) is the best known to the general reader,

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* So named from the absence of teeth in the fore-part of the jaws.

† See the charming volume entitled, "Journal of the Voyage of H. M. S. Beagle," by *Charles Darwin, Esq.*

from the graphic exposition of its configuration and habits by Dr. Buckland; and the splendid remains of its skeleton presented to the Hunterian Museum by Sir Woodbine Parish. But this animal is only one of several species of *Edentata*, equally interesting, and almost rivalling it in magnitude, which the labours of our own naturalists, Sir W. Parish, Mr. Darwin, and Mr. Pentland, and of Dr. Lund, and other foreign savans, have brought to light. I can only advert to two other genera, namely, the *Glyptodon* and *Mylodon*.*

GLYPTODON (*sculptured-tooth*) CLAVIPES. *Lign.* 156.—The bony tesselated carapace, or shield, which was formerly assigned to the Megatherium (*Bd.* I. p. 159.), has been proved, by the discovery of other specimens, to belong to a gigantic animal, whose bones are occasionally found associated with those of the Megatherium, and is closely allied to the Armadillo. This discovery was made by my friend, Sir Woodbine Parish, to whose indefatigable exertions the Hunterian Museum is indebted for its most splendid relics of fossil Edentata.† The teeth

* An able memoir in the Penny Cyclopædia, *Art.* MEGATHERIIDÆ, and another under the title "UNAU," will present the student with an epitome of all that is at present known of these extinct beings.

† A restored figure of the Glyptodon forms the frontispiece of the elegant and interesting volume on "Buenos Ayres and the Provinces of Rio de la Plata; their present State and Trade." By Sir Woodbine Parish, K. C. H. &c.

of this animal, which are eight in number on each side of each jaw, are sculptured laterally, by two

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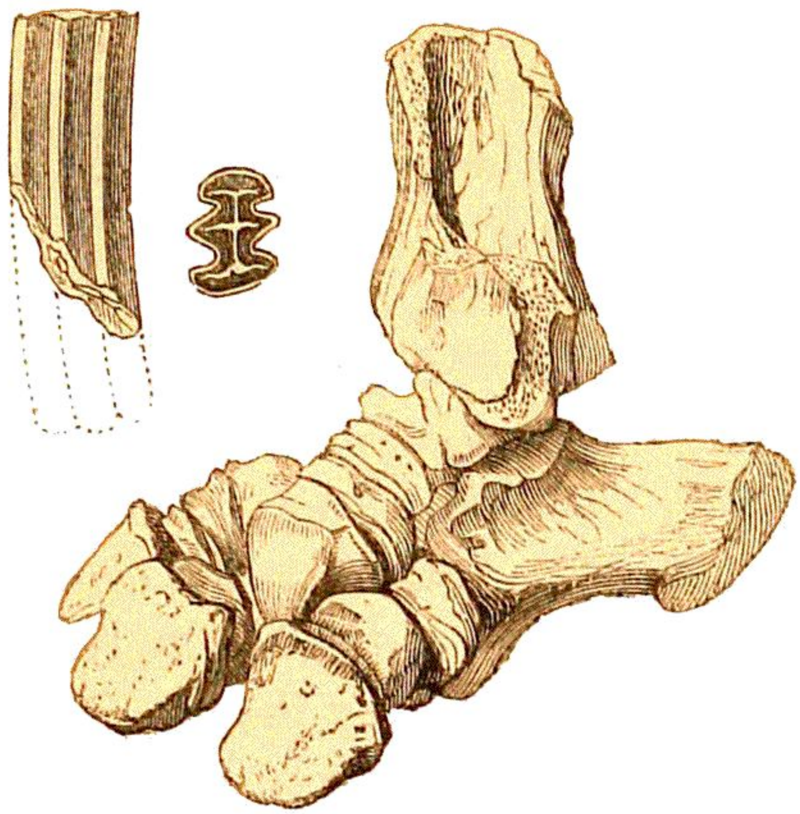

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LIGN. 156. TOOTH, AND BONES OF THE LEFT FOOT OF A COLOSSAL QUADRUPED ALLIED TO THE ARMADILLO.

(GLYPTODON CLAVIPES. *Professor Owen*).

*Discovered near Monte Video, by* SIR WOODBINE PARISH.

Fig. 1.—Side view of a tooth, showing the deep lateral channels. The original four inches long.

2.—Grinding surface of the same.

3.—Outside view of the left hind-foot. Length of the original about fourteen inches, from the heel to the toe.

(*From the Geol. Trans.* Vol. VI. pl. 10.)

wide and deep channels (*Lign.* 156, fig. 1.), which divide the grinding surface of the tooth into three portions (*Lign.* 156, fig. 2.). From this structure of the teeth, Professor Owen has named this animal *Glyptodon.* The hind foot is very peculiar (see *Lign.* 156, fig. 3.), and presents an extreme modification of the same general plan of structure as that of the Armadillo. From the character of the teeth, and other considerations, Professor Owen considers the skeleton of this animal as offering the type of a distinct genus, related to *Dasypus* (Armadillo).*

MYLODON † (*molar-tooth*).—Professor Owen has designated by this name, in a splendid volume, published under the auspices of the College of Surgeons,‡ a gigantic edentate animal, allied to the Sloth, and formerly described as a species of Megalonyx, an almost perfect skeleton of which was obtained from a fluviatile deposit, a few leagues to the north of the city of Buenos Ayres. The animal appears to have

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* A splendid specimen of the bony dermal carapace of the *Glyptodon*, has recently been added to the Hunterian Museum.

† A name intended to express that the animal has only teeth adapted for grinding; but this term is equally applicable to all the other megatherioid animals.

‡ Description of the Skeleton of an extinct gigantic SLOTH (*Mylodon robustus*), &c., by Richard Owen, F. R. S., Hunterian Professor, of the Royal College of Surgeons. 1 vol. 4to., with 24 plates. 1842. The lithographs in this work, by Mr. Scharf (of Francis Street, Tottenham Court Road), are of the highest excellence; the figure of the entire skeleton of the animal, on a scale of two inches to a foot, is admirable.

been imbedded entire, and soon after its death, for the parts of the skeleton were found but little displaced, and the very few bones that are wanting, are such as might easily have escaped the search of the collector. But this magnificent specimen of the extinct fauna of South America must be seen to be properly appreciated. The skeleton measures eleven feet from the fore part of the skull to the extremity of the tail, the latter being three feet in length; the circumference of the trunk around the tenth pair of ribs, is nine feet nine inches; the Megatherium is eighteen feet in length, and its girth fourteen and a half feet. These particulars will serve to convey an idea of the relative size of these gigantic animals. From certain peculiarities in the construction of the skeleton of the Mylodon, Professor Owen, perceiving from the teeth that it was a vegetable feeder, and probably lived on leaves and the tender buds of trees, and its enormous bulk and weight forbidding the assumption that it climbed up trees and suspended itself by the branches, like the diminutive existing Sloths, assigns to this creature the task of uprooting and felling trees, and feeding upon the foliage of the forests it laid prostrate. A remarkable development of the substance of the bones of the skull, is presumed to have been a provision against the fatal effects of a fracture of the cranium, to which the Mylodon, from its supposed uprooting propensities, is conjectured to have been peculiarly exposed; and the skull of the specimen in the College bears proofs of having had two fractures, from both of which the animal recovered. But whoever looks at the skeleton will perceive that the fore-feet are admirably adapted for seizing and wrenching off the branches, and the hinder feet for clasping the trunk of a large tree; and there is nothing to forbid the supposition, that the animal could obtain a constant and ready supply of food, by climbing up the stem to a sufficient height, and wrenching off the branches. Professor Owen states, that the Mylodon unites the two great groups of the *Unguiculata* (animals with nails and claws), and the *Ungulata* (hoofed animals), for it has both hoofs and claws on the same feet.

The dental organs consist of four molars on each side the lower, and five on each side the upper jaw. The teeth are implanted in very deep sockets, and are of the same size and form throughout, with a conical pulp-cavity at the base, indicating that their growth continued during the life of the animal. In structure they resemble those of the Megatherium, and Sloth (*Bradypus*); being composed of a pillar of coarse dentine, traversed by numerous vascular or medullary canals, which is invested with a layer of very fine, dense dentine, with minute calcigerous tubes, and the whole surrounded by a thick coating of cementum: no enamel enters into their composition.*

* Description of the Mylodon, p. 24.

V. FOSSIL RODENTS.—Of the mammalia termed *Rodentia*, or Gnawers (see *Wond.* p. 133.), of which the Mouse and Rabbit are examples, the remains of several genera are found in a fossil state; particularly in the caverns containing the bones of Carnivora. Dr. Buckland collected from Kirkdale Cave, bones of a species of Hare or Rabbit, Mouse, and Water-Rat (*Reliq. Diluv.* pl. 11.).

In the eocene gypseous strata of France, two species of Dormouse and two of Squirrel have been found. From the tertiary sand at Epplesheim, with the bones of the Dinotherium, those of a species of Hamster, or German Dormouse (*Cricetus*) were obtained.

Fossil teeth of a species of Porcupine (*Hystrix*) occur in the pliocene deposits of Tuscany.

Of the Beaver (*Castor*), some undoubted remains have been collected in this country. Those of a species apparently identical with the recent Beaver of the Danube, were discovered by the late Mr. Woodward in alluvial silt, in Norfolk; and Professor Owen states (*Brit. Rep.* 1842.), that the remains of the very large extinct species first observed in Russia (and named by M. Fischer, *Trogontherium*), have been found in the subterranean forest at Bacton, in Suffolk.

VI. FOSSIL MARSUPIALIA.*—That the remains

* Marsupialia; animals that carry their young in a pouch (*marsupium*), as the Kangaroo.

of an extinct species of gigantic *Kangaroo* should be found in the fissures of the rocks, and in the caverns of Australia, a country in which marsupial animals are the principal existing mammalia, is a fact that will not excite much surprise; but that beings of this remarkable type of organization should ever have inhabited the countries situated in the latitude of the European continent and of Great Britain, would never have been suspected, but for the researches of the geologist. The fossil remains of this class discovered in New Holland, occur in fissures and caves, in limestone of the New Red system, imbedded in red ochreous loam, and are often incrusted by stalactitic concretions. One of the species exceeds the largest existing Kangaroo, and its bones are associated with those of the Wombat, and other marsupial animals (*Ly.* I. pp. 310—312.).

A species of Didelphys (*Opossum*) has been discovered in the gypseous limestone of Montmartre, and is described by Baron Cuvier (*Oss. Foss.* Tom. III. pl. 71.). It consists of a considerable part of the skeleton of a small animal, imbedded in a block of gypsum split asunder; some of the bones being attached to the surface of one moiety, and the remainder to the other. From the character of the jaws and teeth, Baron Cuvier pronounced that the animal was related to the Opossum, and confidently predicted, that the two peculiar bones which support the pouch in these animals, would be found attached to the fore-part of the pelvis; accordingly he chiselled away the stone, and disclosed the *marsupial* bones; thus proving the truth of those laws of correlation of structure, which he was the first to enunciate and establish.

In the *Eocene sand* at Kyson, near Woodbridge, in Suffolk, among other mammalian remains, Mr. Colchester, of Ipswich, a gentleman whose researches have been rewarded by many interesting fossils, found a fragment of the jaw, with one premolar tooth having two fangs, of a small animal; and which Mr. Charlesworth (now Curator of the Philosophical Institution of York), with his wonted penetration, pronounced to belong to a marsupial animal allied to the Opossum;* an identification which Professor Owen states is the most probable one.†

But the specimens above described are far surpassed in interest by those discovered in the *Oolite* of Stonesfield, consisting of several jaws and teeth of marsupial animals!

FOSSIL MAMMALIA OF STONESFIELD. *Lign.* 157. (*Bd.* pl. 2. *Ly.* II. p. 55, 56. *Wond.* p. 443.).—The only known examples of the fossil remains of mammalia in the Secondary formations, and consequently those of the highest antiquity on the surface of our planet, according to our present knowledge of the earth's physical history, are several mutilated lower jaws with teeth, of some

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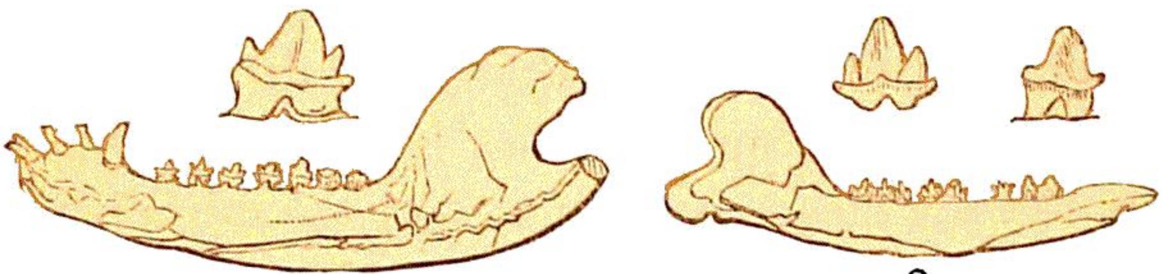
* Mag. Nat. Hist. 1839. On the *Didelphys Colchesteri.*

† Brit. Assoc. Rep. 1842, p. 73.

very small animals, which are supposed to belong to insectivorous and marsupial quadrupeds. These most important organic remains have all been found in the oolitic laminated limestones of Stonesfield; deposits which, as we have already had



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LIGN. 157. LOWER JAWS OF MAMMALIA: *nat. Oolite.* Stonesfield.

Fig. 1.—PHASCOLOTHERIUM* BUCKLANDI. The right branch of the lower jaw, seen from within, with seven grinders, one canine tooth, and three incisors.

2.—AMPHITHERIUM BRODERIPII. The left branch of the lower jaw, the inner side; the incisor and canine teeth are wanting.

The upper figures are enlarged views of three molar teeth.

(*Geol. Trans.* Vol. VI. pl. 6.)

occasion to notice, teem with other relics of great interest. Two specimens of the natural size are represented *Lign.* 157, and will serve for reference to the collector who may visit that interesting locality.†

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* This name signifies *ancient phascolomys;* indicating the affinity of the fossil animal to the *Wombat* of New South Wales.

† To obtain farther information on this subject, Professor Owen's Memoir, and the exquisite accompanying plates, should be consulted. *Geol. Trans.* Vol. VI. pl. 5, 6.

The existence of undoubted mammalia in strata of so remote an epoch, was first made known by Dr. Buckland (in 1823), who, upon the authority of Baron Cuvier, stated that the two specimens then discovered belonged to marsupials allied to the Opossum (*Didelphys*). These fossils were two left branches of two lower jaws, and both were imbedded in the stone by the external surface, the inner side only being visible. One of these specimens had ten molar teeth in a row; the other is the beautiful fossil (now in the British Museum), fig. 1. *Lign.* 157, which has seven molars, one canine tooth, and three incisors. Four other specimens have since been found; and the whole are figured in Professor Owen's *Brit. Foss. Mam.* p. 15—70; with ample details of their anatomical characters, and physiological relations. The Hunterian Professor has clearly demonstrated that the *Amphitherium* had thirty-two teeth in the lower jaw, sixteen on each side; it is presumed to have been insectivorous, and its marsupial affinities are doubtful. The *Phascolotherium* had four true molar teeth, and three or four false molars, one canine, and three incisors in each branch of the lower jaw; and closely approximates to marsupial genera now restricted to New South Wales and Van Diemen's Land. It is, indeed, as Professor Owen remarks, an interesting fact, that the other organic remains of the British Oolite correspond with the existing forms now confined to the Australian continent and neighbouring seas; for in those distant latitudes, the *Cestracionts*, *Trigoniæ*, and *Terebratulæ* inhabit the ocean, and the *Cycadeæ* and *Araucariæ* flourish on the dry land.

Thus we have evidence of the existence of the marsupial order during the Secondary and Tertiary formations; a proof, as Dr. Buckland observes (*Bd.* p. 73.), that this order, instead of being, as was once supposed, of more recent introduction than other orders of mammalia, was, in reality, the most ancient condition under which animals of this class first existed in the earlier geological epochs; that according to the data at present obtained, it was the only type of mammalian organization during the Secondary formations; that it was co-existent with many other orders throughout Europe in the Eocene period; while its geographical distribution in the existing fauna, is restricted to North and South America, and to New Holland, and the adjacent islands.

VII. Fossil Carnivora. — The fossil bones and teeth of numerous species of *Carnivora*, the order comprising the mammalia which prey on other animals, of which the Lion, Tiger, Cat, Dog, &c. are examples, abound in fissures and caverns, in conglomerated rocks, and in drifted sand and gravel. The remains of the colossal Pachydermata, the Mastodons and Elephants, for the most part, as we have previously shown, lie buried in the superficial alluvial deposits; but the Carnivora, although occasionally entombed with the herbivora in Drift, are principally found imbedded in the floors of extensive caverns. In many instances, such immense quantities of bones and teeth of individuals of all ages, and belonging to but one or two species, occur in certain caverns, as to render it probable that these caves were for a long period the dens of the extinct species of Bears, Wolves, Hyenas, Tigers, &c. whose bones they enclose.

Another remarkable geological condition in which fossil Carnivora occur, is that of an ossiferous, or *bone-breccia;* that is, a conglomerate formed of fragments of limestone and bones, cemented together into a hard rock, by a reddish calcareous concretion. This breccia is found in almost all the islands on the shores of the basin of the Mediterranean Sea; as for example, at Gibraltar, Cette, Nice, Cerigo, Corsica, Palermo, &c. The most celebrated ossiferous caverns are situated in Franconia, and in numerous parts of the Hartz. That of Gailenreuth has long been known and remarked for its fossil treasures, which principally consist of the bones and teeth of extinct species of bears. One species is equal in size to a large horse, and is termed *Ursus spelæus* (Bear of the caverns): and skeletons have been found of all ages, from the adult to the cub but a few days old (see *Wond.* p. 165.). There are numerous caverns in the neighbouring district, some of which are equally rich in the remains of

Carnivora.* Similar fossils are also found in the consolidated gravel and drift in various parts of Germany, and in the fissures of rocks containing iron-ore, at Kropp, in Carniola.

Even in Australia, caverns with ossiferous breccia are numerous; but the bones belong to extinct marsupial animals of genera still existing in the country (see *Wond.* p. 179.). In England, several caverns presenting similar phenomena have been discovered. That of Kirkdale, near Kirby Moorside, Yorkshire, is well known from the celebrity it has acquired by the graphic illustration of its contents by Dr. Buckland.† This cave, or rather fissure, for its dimensions were too limited to merit the name of cavern, was situated in oolitic limestone; it was two hundred and fifty feet long, from two to fourteen high, and six or seven wide. The

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* A highly interesting account of the Ossiferous Caves of the Hartz and Franconia, by Sir Philip Grey Egerton, Bart., was published in *Geol. Proc.* Vol. II. p. 94, for 1834, describing the state of those caverns at that time, with a list of the bones collected by the author and Viscount Cole (now the Earl of Enniskillen.)

† Dr. Buckland's celebrated work "Reliquiæ Diluvianæ," contains an admirable description of these caverns and their contents, with numerous plates. The student, in consulting this volume, must separate the *facts*, from the diluvial theory, which, at the period of its publication (1823), they were supposed by Dr. Buckland, and other eminent geologists, to confirm.

floor was occupied by a bed of indurated mud, covered over with a thick crust of stalagmite; the roof and sides being invested with a similar calcareous sparry coating, as is commonly the case in all fissures in limestone rocks.* From this cave were obtained numerous bones of hyenas, associated with bones, more or less fractured, of a species of tiger, bear, wolf, fox, weasel, elephant, rhinoceros, hippopotamus, horse, deer, ox, hare, or rabbit, mouse, water-rat, and fragments of skeletons of ravens, pigeons, larks, and ducks. Many of the bones exhibited marks of having been gnawed, and crushed by the teeth of some animals. From all the facts observed, and which are detailed by Dr. Buckland with his wonted graphic power, it is inferred that the cave was inhabited for a considerable period by Hyenas; that many of the remains found there were of species carried in and devoured by those animals, and that in some instances the hyenas preyed upon each other. The portions of bone referable to the elephant seem to prove that occasionally the large mammalia were also obtained for food; but it is probable that the smaller animals were either drifted in by currents of water, or fell into the chasm through fissures now closed up by stalactitical incrustations. Kent's Cave, near Torquay, Oreston Cave, near Plymouth, and several other caves in

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* For a general description of the cave at Kirkdale, see *Wond.* pp. 169—172; and for details, *Reliq. Diluv.* pl. 1—12.

Devonshire, have yielded great numbers of bones and teeth of Carnivora and of Pachydermata (see *Reliq. Diluv.* p. 67.).

Kent's Cavern, or Hole, is the most productive ossiferous cavern in England, and its vicinity to Torquay renders it easy of access to the student. An extensive collection of fossil bones was obtained from this cavern by the late Rev. J. MacEnery; comprising, in addition to the usual extinct Carnivora, skulls and teeth of a species of Badger (*Meles taxus*), Otter (*Lutra vulgaris*), Pole-cat (*Putorius vulgaris*), Stoat or Ermine (*P. erminius.*).

A selection of the choicest specimens in this collection has been obtained for the British Museum.

In Glamorganshire, two large caverns, called Goat's Hole, and Paviland Cave, containing numerous bones of Bear, Hyena, Wolf, Fox, Rhinoceros, Elephant, &c. are situated in a lofty cliff of limestone, between Oxwich Bay and the Worm's Head, on the property of Earl Talbot, fifteen miles west of Swansea, (*Reliq. Diluv.* p. 82.).

In the western district of the Mendip Hills, in Somersetshire, there are several ossiferous fissures and caves. The most interesting are those of Hutton, on the northern escarpment of Bleadon Hill; and of Banwell, lying about a mile to the east of Hutton. They contain remains of two species of bear, one (*U. spelæus*) of immense size and strength; and of a species of tiger, hyena, wolf, fox, deer, ox, and elephant.*

From the caves at Hutton, the Rev. D. Williams obtained the milk-teeth and other remains of a calf-elephant, about two years old, and those of a young tiger, just shedding its milk-teeth; also the grinders of a young horse, that were casting their coronary surfaces; and remains of two species of hyena.

But one instance of the fossil bones of Carnivora has been observed in the south-east of England. It occurred in a fissure in a quarry of sandstone at Boughton, near Maidstone; among other bones, the lower jaw of a Hyena (see Frontispiece of Vol. I.), with the teeth, were obtained.

In the modern silt of our alluvial districts, the remains of carnivorous animals, formerly indigenous to this island, are occasionally met with; and the skeleton of the Brown Bear (a species which inhabited Scotland eight centuries ago), and of the Wolf, whose extinction is of a yet later date, have been discovered. The Woodwardian Museum at Cambridge contains an entire skull of the Brown Bear (*Ursus arctos*), found in the Manea Fen of Cambridgeshire;† and in an ancient fresh-water

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* See a Memoir "On the Caverns and Fissures in the Western District of the Mendip Hills," by the Rev. D. Williams. Proc. Royal Society, June 2, 1831, p. 55.

† A beautiful lignograph of this specimen is given in Hist. Brit. Foss. Mam. p. 77, fig. 24.

deposit, near Bacton, in Norfolk, the right lower jaw of the Bear of the Caverns (*Ursus spelæus*), has been discovered.*

Thus the remains of fossil Carnivora discovered in England comprise several kinds of Bear, including the two species of the caverns of Germany (*U. priscus* and *U. spelæus*); and of Tiger, Hyena, Wolf, Fox, &c. Although we cannot dwell on foreign localities of Carnivora, I may mention that the lacustrine pliocene formation of Œningen occasionally yields fine remains. A splendid specimen of a fossil Fox, from that locality, in the choice collection of R. I. Murchison, Esq., displays almost the entire skeleton.†

The SEAL, which is a marine carnivorous mammalia, also occurs in a fossil state in England; for a femur of some species of *Phoca* has been found, with the remains of a Monkey and Bat, in a tertiary deposit in Suffolk. In the tertiary strata of Malta an extinct species of Seal has also been discovered.

Of the INSECTIVORA, the fossil remains of several genera occur. In England, the jaw with teeth, of a large species of *Water-mole* (named PALÆOSPALAX, *ancient mole*), has been discovered by that excellent zoologist, Mr. Waterhouse, of the British Museum,‡ in a lacustrine deposit at Ostend, near

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* Hist. Brit. Foss. Mam. p. 89.

† See Geol. Trans. Vol. III. pl. 33: a Memoir by the Author, on a Fossil Fox, from Œningen.

‡ Hist. Brit. Foss. Mam. p. 25.

Bacton, on the coast of Norfolk, associated with bones of Elephant, Deer, Roebuck, and Beaver. This animal, Professor Owen states, must have been as large as a hedgehog. The only part of the skeleton hitherto obtained is a portion of the left side of the lower jaw, containing six molar teeth; its natural affinities have therefore been inferred from the characters of the crowns of the teeth.

The CHEIROPTERA (*hand-wing*), are mammalia which have the power of flight, from the bones of the phalanges or fingers being enormously elongated, and giving support to a fine membranous expansion; they are rarely found fossil, although from the habits of Bats of haunting and hybernating in fissures and caves, their skeletons often occur mingled in the earth of the floor of caverns with genuine fossil bones, and imbedded in crannies of rocks.

The remains of a considerable portion of the skeleton of one species of Bat was discovered by Baron Cuvier, in the gypsum of Montmartre;* and another example, also in a gypseous deposit, at Köstritz, in Germany, with those of extinct species of other mammalia. Professor Owen adduces, what he considers to be two unequivocal instances of British fossil Bats; the one from Kent's Cavern, collocated with the extinct Carnivora, and referred to the Horse-shoe Bat (*Rhinolophus*); the other from

* Discours sur les Révolutions de la Surface du Globe, par Baron G. Cuvier, 1 tom. 4to. 1826. Pl. II. fig. 1.

Kyson, in Suffolk, found in the same deposit with the remains of the Monkey, presently to be noticed, and related to a tropical species of *Molossus*.*

VIII. FOSSIL QUADRUMANA, OR MONKEYS.—The illustrious Cuvier, when commenting on the extraordinary fact, that among the innumerable fossil relics of the mammalia which peopled the continents and islands of our planet, through the vast periods comprehended in the tertiary formations, no traces of MAN or of his works occur, emphatically remarked, that it was a phenomenon not less surprising, that no remains of the quadrumanous races, which rank next to Man in physical conformation, should have been found in a fossil state; and that the circumstance was the more remarkable, because the majority of the mammalia found in the drift, and in the tertiary strata, have their congeners at the present time in the warmest regions of the globe; in those intertropical climates where the existing quadrumana are almost exclusively located.†

FOSSIL APE OF FRANCE.—But the remains of this order have at length been discovered in the most ancient of the tertiary deposits, and under circumstances which admit of no doubt as to the antiquity of the fossils or the strata in which they were imbedded; and almost at the same time in

* Brit. Assoc. Rep. 1842.

† Discours sur les Révolutions, p. 171.

France, and in the Himalayas; and very recently in the Brazils, and in England. The first European specimen was discovered at Sansan, near Auch, about forty miles west of Toulouse, by M. Lartet, with remains of the Rhinoceros, Deer, Antelope, Palæotherium, &c. It consists of the lower jaw, almost complete, with all the teeth, of an adult animal, of an extinct species, related to the long-limbed and tailed monkey, called *Semnopithecus*, of which the Negro Monkey is an example. A fragment of another jaw has been found in the same locality.

FOSSIL MONKEY OF THE SUB-HIMALAYAS.—In the inexhaustible mine of fossil bones, discovered by British Officers in India, the upper-jaw of an Ape was found by Messrs. Baker and Durand, and fragments of other jaws, and some bones, were subsequently collected by Dr. Falconer and Captain Cautley. These relics conjointly established the existence of a gigantic quadrumanous animal in the groves of India at the Eocene epoch, when the gigantic Tortoise, the lofty Sivatherium, and the colossal Mastodon tenanted the plains, and Hippopotami frequented the marshes and rivers. This fossil Ape also is related to the *Semnopithecus*.

FOSSIL MONKEY OF SOUTH AMERICA.— Dr. Lund, the eminent Danish naturalist, to whose indefatigable researches, and successful determination of the colossal Edentata, we have previously alluded, has discovered the bones of a gigantic Ape, four feet in height, related to the Capuchin Monkey, in the ossiferous breccia of the caves of Brazil.

British Fossil Monkey, *Ly.* I. p. 344.—The first fossil relic of a quadrumanous animal from the British strata was obtained in 1839, from a bed of Eocene sand, at Kyson, a few miles east of Woodbridge, in Suffolk, by W. Colchester, Esq. The first specimen found consists of a small fragment of the right side of the lower jaw, with the last molar tooth entire in its socket; the only other relic is the crown of one fang of the first molar tooth, of the same species. Professor Owen, after an elaborate investigation of these fossils, refers them to an extinct Monkey, related to the *Macacus;* and designates the species, *Macacus eocænus* (Eocene Monkey), in allusion to the geological age of the stratum in which the remains were discovered.* It is an interesting fact, that in the clay overlying the bed of sand in which the Monkey's teeth were found, a vertebra of the fossil serpent (*Palæophis*, see p. 780.), and several teeth of a Pachyderm (*Hyracotherium*), both of which occur in the London Clay of Sheppey, were discovered; thus proving the geological age of the deposit (*Ly.* I. p. 344.).

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* See British Fossil Mammalia, p. 1, figs. 1, 3.

ON COLLECTING AND DEVELOPING THE FOSSIL REMAINS OF MAMMALIA.—But few directions for the developing and repairing of the fossil remains of mammalia will be required in this place, the suggestions already offered, and particularly those in Vol. I. pp. 56—62, embracing full instructions on this head. On the method recommended in p. 57, for strengthening the friable bones of the large mammalia, I may observe, that the *drying-oil* is composed of *litharge* dissolved in oil; in the proportion of one ounce of the litharge to a pint of oil.

The search for fossils of this class is attended with much less certainty of success than that of the other animal remains. I know not one accessible British locality where the collector may depend on obtaining interesting specimens of mammalian teeth and bones. In the following list, the localities most likely to be productive are enumerated; but we have no caverns, as in Germany, so rich in remains of this kind, as to ensure the discovery of specimens by the casual visitor; for the treasures of the most productive cave, that of Banwell, are prohibited: the proprietor carefully preserving every fragment. A short residence near some of the best localities, and daily research, are required for obtaining interesting specimens. For example, a residence at Ryde, for a search in the fresh-water tertiary limestone at Binstead; at Torquay, for Kent's cavern; or some other town or village near the other caves in Devonshire; Herne Bay, for the London Clay at Studd's Hill, that produced the Hyracotherium; Woodbridge or Kyson, for the Suffolk mammalia; Walton, in Essex (see *Wond.* p. 145.), for remains of Elephants in the clay.

In searching for bones and teeth in an unexplored cave, the following suggestions by Dr. Buckland will be found of great value. Select the lowest parts in the cavern or fissure, into which any mud or clay can have been drifted or accumulated; and then break through the stalagmitic crust of the floor, and dig down into the silt and pebbles, &c. below, in which bones and teeth will be found, if the spot contains any relics of this kind. As a test for distinguishing the ancient bones found in these caves, from those which may have been recently introduced, the tongue should be applied to them when dry, and they will adhere in consequence of the loss of their animal gluten, without the substitution of any mineral substance, such as we commonly find in the fossil bones of the regular strata. Human bones found in caves always possess too much animal gluten to adhere to the tongue when dry.*

Along the eastern coast of England, and often off the mouth of the Thames, the fishermen dredge up teeth, tusks, and bones of Elephants; and good specimens may sometimes be thus procured. The

* Dr Buckland on Fossil Bones of Bears in the Grotto of Osselles, near Besançon, in France. *Geol. Proc.* Vol. I. p. 21.

Ramsgate fishermen employed in trawling in the North Sea and English Channel, frequently bring up in their gear fragments of fossil bones of Mammoths, and other mammalia. From the bank of the Goodwin-sands, large tusks have been procured. On the shore near Herne Bay, very fine mammalian remains are occasionally obtained. In the Museum at Canterbury, there was (and I believe is) a good collection of fossil bones of large Pachydermata procured from the neighbouring coast. It is a remarkable fact, that immense quantities of the bones of Mammoths, or fossil Elephants, are strewn over the bed of the German Ocean and English Channel. The late Mr. Woodward informed me, that the teeth and tusks of Elephants collected along the Norfolk and Suffolk coasts, within his own cognizance, must have belonged to upwards of five hundred individuals.

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## BRITISH LOCALITIES OF FOSSIL MAMMALIA.

Bacton, Norfolk. See *Ostend.*

Banwell Cave, fifteen miles from Bristol. Bones and teeth of Bears, Hyenas, Felis larger than the Lion; ossiferous breccia.

Berry Head, Devonshire; Cave. Carnivora; as Bear, Badger, Tiger, Pole-cat, Stoat.

Binstead, near Ryde, Isle of Wight. *Tert.* fresh-water limestone. Teeth and bones of Anoplotherium, Palæotherium, Chæropotamus, Dichobune.

Brighton Cliffs. Between Kemptown and Rottingdean, in the beds above the Chalk. Teeth and bones of Elephant, Horse, Deer, Oxen; jaw of a Whale. *Rare.*

Crayford, Kent. In Drift. Elephant, Horse, &c.

Easton, a mile and a half north of Southwold. Mastodon tooth, and Carnivora.

Harwich, Essex. Elephant's teeth, &c.

Herne Bay. In *London clay;* Hyracotherium, Chæropotamus. In alluvial clay and drift; Elephant, Whale.

Hoe, near Plymouth, raised Beach at. Elephant, Rhinoceros, Bear, Deer, Whale, &c.

Horstead, Norfolk. In alluvial drift. Mastodon tooth.

Hutton Caves, near Banwell, Somersetshire. Carnivora, Pachydermata, &c. See p. 857.

Isle of Man. The Irish Elk (*Cervus euryceros*).

Kent's Cave, near Torquay. The most productive of the British ossiferous caverns (see p. 857.). Bear, Badger, Tiger, Wolf, Fox, and other Carnivora; Rhinoceros, Elephant, and other Pachydermata.

Kirkdale, by Kirby Moorside, Yorkshire (see p. 855.). I know not if any accessible part of this celebrated cave remains.

Kyson, near Woodbridge, Suffolk. On the side of the river Deben, about a mile from Woodbridge, in the parish of Kyson (Kingston). The strata consist of, 1. Red crag, the uppermost. 2. London clay, about twelve feet. 3. White and yellow sand. In this lower bed the relics of *Monkey, Didelphys, Bat, Gigantic Mole.*

Manea Fen, Cambridgeshire. Skull of Bear.

Newbourn, Suffolk. *Mastodon tooth.* Leopard.

Norwich. In alluvial silt. Mammoth's teeth and bones.

Oreston Cave, near Plymouth. Carnivora, Wolf, Bear, Hyena, &c.

Ostend, near Bacton, on the coast of Norfolk. In a lacustrine deposit of dark clay and greenish sand, with charred trunks and branches of trees. A section presents—1. Uppermost Drift. 2. Black earth, with shells. 3. Reddish sand. 4. Norwich crag, in patches. 5. Chalk. Nos. 2 and 3 are lacustrine; and in these beds have been found

Gigantic Mole (*Palæospalax*), Elephant, Deer, Roebuck, fossil Beaver (*Trogontherium*), jaw of Bear (*Ursus spelæus*). See Hist. Brit. Foss. Mam. p. 85.

Paviland Cave, fifteen miles west of Swansea; between Oxwich Bay and the Worm's Head, Glamorganshire. Rhinoceros, Mammoth, Hyena, Wolf.

Plymouth. Caverns near elevated Beach, at the Hoe. Elephant, Rhinoceros, Bear, &c.

Postwick, near Norwich. In Drift. Tooth of Mastodon.

Seafield, Isle of Wight. *Tert.* Palæotherium.

Southbourn, Sussex. The plain of alluvial mud and clay, called the "*Wish*," a section seen on the sea-shore between the Sea-houses and the foot of the chalk hills. Elephant, Hippopotamus, Deer, Horse, Ox.

Southwold, Suffolk. In Drift. Elephant, Rhinoceros, Horse, Deer, Mastodon; Otter, in red Crag.

Stonesfield, near Woodstock, Oxfordshire. *Oolite.* The only known locality of fossil remains of mammalia. See p. 851.

Studd Hill, a mile westward of Herne Bay. London clay. *Hyracotherium.* See p. 835.

Swansea (Paviland Cave, near). See Paviland.

Wirksworth, Dream Cave. A perfect skull of Rhinoceros, in Dr. Buckland's museum, at Oxford.

Woodbridge, Suffolk. At Kyson, near Woodbridge. Teeth of Monkey, &c.

## BONE CAVES IN FRANCONIA.

*** CAPTAIN WILLOUGHBY MONTAGU having favoured me with an account of the state of the principal caves in Franconian Switzerland, which he visited last summer, the subjoined extract may be useful to the continental traveller. The newly-discovered cave of *Sophienhöhle* appears to be highly interesting; the stalactites remaining uninjured, and the ossiferous floor in the state in which it was discovered: the much-frequented caverns being stripped of every relic by the spoliations of visitors during the last century and a half.

"The northern part of Bavaria, which is denominated 'Franconian Switzerland,' is situated about the centre of a triangle, formed between Bamberg on the N.W., Bayreuth N.E., and Nuremberg S.; the best road from this latter city diverging beyond Erlangen to the north.

"The nearest route from London is through Belgium, from Ostend or Antwerp, by the line of railroad which (since October, 1843) passes on from Liege and Verviers, by Aix-la-Chapelle to Cologne. Thence by steam up the Rhine, by Coblentz to Mayence, and again by railway to Frankfort. In summer there are steam-boats up and down the Maine, as far as *Wurzburg* daily, and higher up, *between* Schweinfurt and Bamberg, which latter distance is performed in eight hours going up, and five down. Or there is a diligence (*eil-wagen*) from Frankfort direct to Nuremberg, from which place (or Bamberg, &c.) a carriage must be hired to Muggendorf, the principal village of that interesting district. It lies about half way on the post road between Erlangen and Bayreuth, and has two tolerable country inns; the people are civil, and moderate in their charges, at least for the freshest trout, and good wine of Bavaria.

"This charming spot and neighbourhood attracts not only the geologist and lover of the picturesque, but also the angler, who finds excellent fishing in the clear, rapidly-winding stream of the Wiesent, with its tributary waters, all of which are romantically placed in the suddenly deep dales of this table-land. The Wiesent flows through Forchheim into the Regnitz, westward, and this into the Maine, north.

"As to the time necessary to get there, during the summer days, it would only require one, to pass through Belgium to Aix, including the transit of this frontier into Prussia, with slight search of baggage. Then, in between four and five hours to Cologne, where the steamers generally wait for the arrival of these trains; and, taking the first boat up, it is possible to reach Bingen (if not Mayence late) the same evening. From Frankfort, by diligence, starting at 11 A.M., and travelling all night, Nuremberg may be reached on the second day; and the centre of operations, about Muggendorf, on the fifth from quitting the sea-coast. In returning by the Maine,—from Wurzburg to Mayence may be performed in one long day,—and then on the Rhine, the descent being much quicker than the upward course against the streams, the return homewards may be accomplished in one day less.

"The nearest way to Ostend is by the South-Eastern Railroad to Dover, and embark for Belgium.

"The newly-discovered cave, called *Sophienhöhle*, lies on the right bank of a streamlet, which gives its name to a romantic and rocky valley, *Ahorn-thall*, and flows S.W. toward Gösweinstein, till it falls into the Wiesent. The situation of the cave is near Klausteinerhöhle, and opposite to *Ludwigshöhle*; and is far easier of access than Gailenreuth, and may be inspected by ladies with the greatest facility. An intelligent female showed us through its lofty and interesting details. This cave is nearly 300 feet wide, and 150 feet in height. The quantity of fossil bones strewed about the floor was very great, notwithstanding many of the finest specimens had been removed, and were to be seen in the neighbouring castle of Count S——; added to this, the long, pendant curtains of stalactite, and the stupendous size of the cavern, contributed to make it appear to me far surpassing in interest that near Gailenreuth, called *Zoolithen-Höhle*, which I had visited the day before. The keys of this cavern, for this, as well as the other celebrated caves, is locked up, to guard against depredations, are kept at the large farm, or steward's house, hard by. The state of the weather prevented our visiting Förstershöhle (*Forest Cavern*), which lies further N.E., beyond the little town of Weischenfeld, near Zeubach; but which, we were informed, was equal in interest to this of Sophienhöhle. The tourist desirous of visiting this interesting district, will find Mr. Murray's Handbook of Southern Germany, an excellent guide: I can vouch for its accuracy."

## RETROSPECT.

"Ce que nous connaissons, est peu de chose; ce que nous ignorons est immense."

LA PLACE.

WE have now arrived at the close of this argument; we have taken a general survey of the fossilized relics of the various classes of the animal and vegetable kingdoms, and have explained the methods by which the inscriptions on these "Medals of Creation" may be deciphered.

But numerous as are the facts which have passed in review before us, and great as the accession of geological knowledge has been during the last fifty years, the data hitherto obtained are insufficient to explain many of the obscure pages of the earth's physical history; and to future times, and to future discoveries, must be left the full interpretation of those phenomena of which we can obtain but imperfect indications; for at present the mystic ground of things unknown, is carried only a remove beyond its former boundary.

In vain we endeavour to penetrate the veil which shrouds from our view many of the mighty events that preceded the history of our race—for although the shades of colossal and unknown forms belonging to the remote ages of a past eternity, obey the spell of the true magician *Science*—yet of the innumerable beings, which through countless centuries,

> "The Earth has gathered to her breast again,
> And yet again, the millions that were born
> Of her unnumbered, unremembered tribes—"

how few, comparatively, could even the transcendent genius of Cuvier reveal!

If we endeavour to trace the order of succession of animal and vegetable organization upon the earth, as demonstrated by fossil remains, we are at once impressed with the insufficiency of the data hitherto obtained, to present us with a true picture of the full development of organic life as it existed in the remotest ages. Ascending from the *Granite*—that shroud which conceals for ever from human ken the earliest scenes of the earth's physical drama—the first glimpses we obtain of animated nature, are a few sea-weeds and shells, and crustacea. But can we doubt for a moment that *that* ancient sea had its boundaries and its shores—that then, as now, there were islands and continents, and hills and valleys, and streams and rivers, teeming with appropriate inhabitants? The single drifted dicotyledonous leaf, in the Carboniferous sea, affords as certain indication of dry land, as the olive branch which the dove brought back to the Ark; one fact of this kind overthrows a host of theories based upon negative evidence.

Advancing upwards, organic life presents more numerous modifications, but no traces of the highest orders of the animal kingdom are apparent, until, on the sands of the ancient Triassic ocean, we behold appearances as unexpected and startling, as the human footstep to Crusoe on his desolate island —the tracks of bipeds—colossal birds—of which no other vestiges remain, and to which the existing order of creation affords no parallel.

We now enter upon that marvellous epoch, during which reptilian organization obtained its fullest development—when the Iguanodon and Megalosaurus—

> "Mighty Pre-Adamites who walk'd the earth,
> Of which ours is the wreck—" BYRON.

were the principal inhabitants of vast islands and continents. But here, as in the earlier periods, we have proof that warm-blooded animals existed; and the diminutive marsupial and insectivorous Mammalia of the Oolite, the Heron of the Wealden, and the Albatross of the Chalk, attest that the system of animal creation was complete.

Leaving behind us the Age of Reptiles, we approach that of the colossal Mammalia, when extensive countries were peopled by the enormous herbivorous Megatheria, the Mastodons, and other gigantic Pachydermata, long since become extinct. But with these lost races many existing species were contemporary; including the Monkey tribes, which, of all animals, approach nearest to man in their physical organization. Thus, by slow, and almost insensible gradations, we arrive at the present state of animate and inanimate nature. But even after the existing continents had attained their present configuration, in the period immediately antecedent to the human epoch, innumerable tribes of carnivorous animals swarmed throughout the temperate climates of Europe; the Tiger lurked in the jungle; the Lion slept in his lair; the Hyena prowled through the woods; the Bear inhabited the caverns; and gigantic elks, oxen, horses, and deer, tenanted the plains.

But of MAN, and of his works, not a vestige appears throughout the vast periods embraced in this review. Yet were any of the existing islands or continents to be engulphed in the depths of the ocean, and loaded with marine detritus, and in future ages be elevated above the waters, covered with consolidated mud and sand, how different would be the characters of those strata from any which have preceded them! Their most striking features would be the remains of Man, and the productions of human art—the domes of his temples, the columns of his palaces, the arches of his stupendous bridges of iron and stone, the ruins of his towns and cities, and the durable remains of his earthly tenement imbedded in the rocks and strata—these would be the "Medals of Creation" of the *Human Epoch*, and transmit to the remotest periods of time, a faithful record of the present condition of the surface of the earth, and of its inhabitants.*

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* See Sir H. Davy's Last Days of a Philosopher.

# APPENDIX TO PART II.

## PROFESSOR OWEN'S CLASSIFICATION OF THE ANIMAL KINGDOM.

(*From the Hunterian Lecture for* 1843.)

Kingdom—ANIMALIA (*animals*).

Sub-kingdom—VERTEBRATA (*having a spinal column*).

Class—MAMMALIA (*animals that give suck*).
AVES (*birds*).
REPTILIA (*reptiles*).
PISCES (*fishes*).

Sub-kingdom—ARTICULATA (*having external-jointed skeletons*).

Class—CRUSTACEA (*having an external crust, or hard skin*).
ARACHNIDA (*spiders*).
INSECTA (*insects*).
ANNELLATA (*composed of rings*).
CIRRIPEDIA (*having curled feet*).

Sub-kingdom—MOLLUSCA (*soft animals*).

Class—CEPHALOPODA (*feet around the head*).
GASTEROPODA (*feet under the belly*).
PTEROPODA (*winged-feet*).
LAMELLIBRANCHIATA (*with lamellated gills*).
BRACHIOPODA (*arm-like feet*).
TUNICATA (*enveloped in a cloak*).

Sub-kingdom—RADIATA (*radiated animals*).

NEMATONEURA (*with thread-nerves*). ACRITA (*with indistinct nerves*).

Class—RADIARIA (*rayed animals*).

ECHINODERMA (*having a spinous skin*). ACALEPHA (*with a stinging skin*).

Class—POLYPI (*polypes*).

CILIOBRACHIATA (*with ciliated arms*). ANTHOZOA (*flower animals*). NUDIBRACHIATA (*with naked arms*).

Class—ENTOZOA (*internal animals*).

CŒLELMINTHA (*hollow worms*). STERELMINTHA (*solid worms*).

Class—INFUSORIA (*infusorial animalcules*).

ROTIFERA (*wheel animalcules*). POLYGASTRIA (*with many digestive sacs.*)

# LIST OF LIGNOGRAPHS,

## ILLUSTRATIVE OF FOSSIL ZOOLOGY.

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## ILLUSTRATIVE OF GEOLOGICAL EXCURSIONS.

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# PART III.

## NOTES OF EXCURSIONS,

IN ILLUSTRATION OF THE

MODE OF INVESTIGATING GEOLOGICAL PHENOMENA,

AND OF COLLECTING

ORGANIC REMAINS.

# GEOLOGICAL EXCURSIONS.

——— "Let the moon
Shine on thee in thy solitary walk;
And let the misty mountain winds be free
To blow against thee; and in after years,
When these wild ecstasies shall be matured
Into a sober pleasure—when thy mind
Shall be a mansion for all lovely forms,
Thy memory be a dwelling place
For all sweet sounds and harmonies, oh! then
If solitude, or fear, or pain, or grief
Should be thy portion, with what healing thoughts
Of tender joy wilt thou remember me
And these my benedictions!' WORDSWORTH.

I NOW propose to conduct the reader to a few British localities, and point out the mode of examining geological phenomena in the field, and of collecting organic remains from the rocks and strata; in other words, afford a practical illustration of the advantages to be derived from the knowledge acquired by our previous investigations. But from want of space, only one or two excursions can be described in detail; and I must restrict myself in a great measure, to extracts from my note-book, and explanatory remarks and suggestions for the guidance of the student and collector. The subjects will be arranged in the following manner:—

1. Instructions for collecting specimens.

2. Excursions illustrative of the geological character, and organic remains of the Tertiary deposits of the London Basin; namely, to the Isle of Sheppey, Bracklesham Bay, &c.

3. Notes for a geological Excursion over the Chalk and Wealden districts of the South-east of England; from London by Tilgate Forest, to Brighton. Also, from Brighton to Rottingdean.

4. Geological notes of various places on the line of the Great Western Railway, from London to Clifton.

5. Excursion to Matlock and its vicinity; to examine the nature and position of the Mountain limestone and associated strata of that part of Derbyshire.

6. Geological Notes for an examination of the central group of the plutonic or igneous rocks of England, and of the Carboniferous and Slate strata, through which they are protruded; in an Excursion to Charnwood Forest, by Leicester, Mount Sorel, Swithland, Woodhouse, &c. to Whitwick.

# CHAPTER XXI.

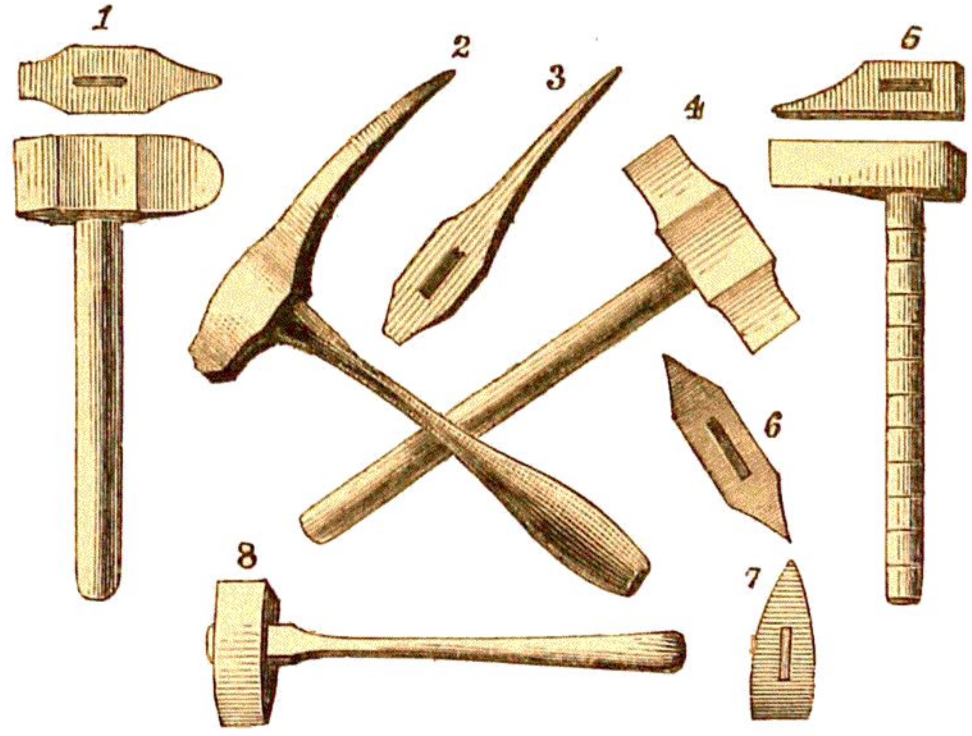
## GENERAL INSTRUCTIONS FOR THE COLLECTION OF SPECIMENS.

> "And some rin up hill and down dale, knapping the chucky stones to pieces wi' hammers like sae many road-makers run daft—they say 'tis to see how the world was made."
>
> ST. RONAN'S WELL.

BEFORE we proceed on a geological excursion, it is necessary to be provided with suitable instruments to detach specimens from the rocks, and extract fossils from the strata in which we may find them imbedded; and with materials for packing up our treasures, and noting their localities on the spot. For this purpose, the following articles will be found more or less requisite, according to the particular object of the collector:—

1. A hammer of one of the forms figured in *Lign.* 158. Fig. 3. will be found most generally useful.

2. A leather or strong camlet bag, and one or two of smaller size; the former with strings, or




LIGN. 158. GEOLOGICAL AND MINERALOGICAL HAMMERS.

Fig. 1 and 4, 6, are adapted for breaking large stones or masses of hard rock; the thinner ends are convenient for splitting and trimming fragments to a moderate size. The head should be from four to five inches long, one and a half inch wide on the crown, and from two to three pounds in weight; the length of the handle from eighteen to twenty inches.

2 and 3.—This is my favourite hammer, and will be found most generally useful; the short square head for breaking, and the pick for splitting stones, and extracting fossils of moderate size; weight of the head two pounds, length seven inches; width of the crown one and a half inch; handle from twelve to fourteen inches long, and one inch wide at the lower part, for the convenience of a firm hold. If the handle be graduated as a foot measure, as in fig. 5, it will be found useful.*

5 and 8, 7, are smaller hammers for breaking and chipping stones and minerals; the heads from three to four inches long, and one and a half pound in weight; the handle one foot long.

* Hammers of this kind may be obtained at Messrs. Knight's, Foster-lane, London; and at 49, Cockspur-street, Charing Cross; care should be taken that the heads are of well tempered steel, and the handles of tough wood.

with a strap for the shoulder. If travelling in a carriage, a box or basket may also be provided.

3. Stout and thin paper, and some of a soft kind, for wrapping up specimens.

4. Chip boxes, and raw cotton, wadding or tow, for the same purpose.

5. String, sealing-wax, writing paper gummed on one side for labels to affix to specimens on the spot.

6. A strong pair of gloves, and a pair of eye preservers; common spectacle frames covered with fine black crape will be more agreeable than glass.

7. A measuring tape, a pocket compass, and drawing materials, will be required, if the observer intend to note the geological characters of the district.

8. A good geological map of the country; if this cannot be procured, the best geographical map.

9. A strong double-bladed knife; one or more chisels.

10. A pocket set of single lenses of three powers, to examine minute objects; blank memorandum books.

Such are the articles that will be required for a geological excursion intended to comprehend a scientific examination of a district; but for a mere trip to collect fossil remains, several may be dispensed with. Some years since, an eminent geologist, Dr. Fitton, drew up some excellent instructions for collecting specimens, for the use of the party employed under Captain King to survey the Western coast of Australia; by the permission of the distinguished author, they are here subjoined.*

## INSTRUCTIONS FOR COLLECTING GEOLOGICAL SPECIMENS.

"It may be proper to premise, that two of the principal objects of geological inquiry are, to determine—1st, the nature of the *materials* of which the earth is composed: and, 2dly, the relative *Order* in which these materials are disposed in relation to each other.

"1. Specimens of rocks ought not, in general, to be taken from loose pieces, but from large masses in their native place, or which have recently fallen from their natural situation.

"2. The specimens should consist of the stone unchanged by exposure to the elements, which sometimes alter the characters to a considerable depth from the surface. Petrifactions, however, are often best distinguishable in masses somewhat decomposed; and are thus even rendered visible, in many cases, where no trace of any organized body can be discerned in the recent fracture.

"3. The specimens ought not to be very small;—about three inches square, and three quarters of an inch in thickness, is a convenient size.

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* For the collection of rock specimens, and for the mode of observing the phenomena of physical geology, Sir H. De la Beche's instructive volume, "*How to observe Geology*," should be consulted.

"4. It seldom happens that large masses, even of the same kind of rock, are uniform throughout any considerable space; so that the general character is ascertained by geologists who examine rocks in their native places, from the average of an extensive surface. A collection ought therefore to embrace specimens of the most characteristic varieties; and *the most splendid examples are, in general, not the most instructive.* Where several specimens are taken from the same place, a series of numbers should be added to the note of their locality.

"5. One of the most advantageous situations for obtaining specimens, and examining the relations of rocks, is in the sections afforded by cliffs on the sea-shore; especially after recent falls of large masses. It commonly happens that the beds thus exposed are more or less inclined; and in this case, if any of them be inaccessible at a particular point, the decline of the strata will frequently enable the collector to supply himself with the required specimens, within a short distance.

"6. To examine the *interior* of an unknown country, more skill and practice are required: the rocks being generally concealed by the soil, accumulations of sand, gravel, &c., and by the vegetation of the surface. But the strata are commonly disclosed in the sides of ravines,—in the beds of rivers and mountain-streams; and these, especially where they cross the direction of the strata, may be found, by careful examination, to afford instructive sections."

The mud and gravel in the beds of rivers, and deltas, often contain grains of *gold*, *platina*, and other native metals, rubies, sapphires, and other precious stones; and a general knowledge of the rocks of an unexplored country often may be gained from the detritus at the embouchure of a river.

"7. Among the contents of the strata, the remains of organized bodies,—shells, corals, and other zoophytes,—the bones and teeth of animals,—wood, and the impressions of vegetable stems, roots, or leaves, &c. are of the greatest importance; affording generally the most marked characters of the beds in which they occur. These should, therefore, be particularly sought after, and their relative abundance or rarity in different situations noticed. The fossils should, if possible, be kept united with portions of the rock or matrix in which they are found; and where they are numerous,—in sand, clay, or any moist or friable matrix,—it is, in general, better to retain a large portion of the whole mass, to be examined afterwards, than to attempt their separation at the time of collecting.

"8. The *loose substances* which are found above the solid rocks, in the form of gravel, silt, rolled pebbles, &c., should be carefully distinguished from the *solid strata* upon which they rest. And the more ancient of these water-worn materials, found on the sides or summits of hills, &c. should be distinguished from the recent mud, sand, and gravel, brought down by land-floods, or by rivers. The bones and teeth of quadrupeds are not unfrequently found in the more ancient gravel; and the collection of these remains from distant quarters of the globe, is an object of the greatest interest to geology.

"9. Besides a note of the locality, there ought, if possible, to accompany every specimen, a short notice of its geological circumstances; as, for example, whether it be found in large, shapeless masses, or in strata? If in strata,—what are the thickness, inclination to the horizon, and direction with respect to the compass, of the beds? If these cannot be measured, an *estimate* should always be recorded while the objects are in view. Are they uniform in dip and direction?—curved, or contorted?—continuous, or interrupted by fissures or veins? Is the whole cliff, or mass of strata in sight, of uniform composition?—or does it consist of different kinds of stone? If the strata be different,—what is the order in which they are placed above each other successively?

"10. A *label*, distinctly written, should accompany every specimen, stating its native place, its relative situation, &c.

and these labels should be attached to the specimens immediately, on the spot where they are found. This injunction may appear to be superfluous; but so much valuable information has been lost to geology from the neglect of it, that every observer of experience will acknowledge its necessity. It is useful to mark on the labels the day, and even the hour, when each specimen is collected. This, with a corresponding note in the memorandum-book, prevents confusion, and will be found to assist the memory.

"11. A *sketch* of a coast or cliff, however slight, frequently conveys more information respecting the disposition and relations of rocks, than a long memorandum. If numbers, denoting the situation of the specimens collected, be marked upon such sketches, much time may be saved at the moment of collecting. But in all such cases, the memorandum should be looked over soon afterwards, and labels, distinctly explaining their situation, &c. be attached to the specimens.

"12. The specimens should be so packed, that the surfaces may be defended from exposure to air, moisture, and friction: for which purpose, if strong paper cannot be obtained, dry moss, or straw, or leaves, may be employed. Where paper is used for wrapping the specimens, they are best secured by fastening the envelope with sealing-wax.

"Lastly. The collector must not be discouraged, nor be prevented from collecting, by finding that the place which he may chance to visit in a remote situation, has not a striking appearance, or the rocks within his view a very interesting character; *since it frequently, and even commonly, happens, that facts and specimens, in themselves of very little importance, become valuable by subsequent comparison; so that scarcely any observation, if recorded with accuracy, will be thrown away.*"

These general instructions will suffice to prepare the reader for an excursion to some known locality, where his researches will certainly be rewarded by many interesting organic remains; and he may be so fortunate as to meet with some rare fossils, and perhaps with one or two that have not previously been discovered; for there is always a chance of finding relics hitherto unknown, even in a cliff or quarry that is daily visited by collectors. And as an old sportsman desirous of inspiring a novice with a love of field sports, takes him at first to preserves where game is plentiful, in like manner I would initiate my reader in the delightful pursuit of collecting the "Medals of Creation," by conducting him to a spot where these antiquities of nature are scattered about in great profusion and variety.

# CHAPTER XXII.

## EXCURSIONS ILLUSTRATIVE OF THE GEOLOGICAL CHARACTERS, AND ORGANIC REMAINS, OF THE TERTIARY DEPOSITS OF THE LONDON BASIN.

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In leaving London for any part of England, the reader will remember that the area on which the metropolis is situated, as well as the surrounding district to a distance varying from a radius of ten to twenty or thirty miles, consist of the marine Tertiary *eocene* strata (see p. 32.), which have been deposited in, and still occupy, a depression, or excavation of the Chalk, called the *London Basin* (*Wond.* p. 210.). Around this formation, the Chalk forms a distinct boundary, on the south, west, and north, rising up into chains of hills or downs; but on the east, the range is broken, and the Tertiary basin lies open to the sea, affording a passage for the Thames and its tributary streams. From this geological character of the metropolitan district, it results, that all the lines of railroad proceeding from London, traverse, for the first ten or twenty miles, beds of clay, loam, and loosely aggregated sand and gravel; hence the numerous slips that have taken place in the embankments; as for example, at New Cross, Wandsworth Common, near Hanwell, &c.; and in all these lines, it is obvious, from the nature of the strata, and the steepness of many of the cuttings, that similar catastrophes will again occur.

The next geological feature observable in the lines of all the London railroads is the CHALK, which is invariably passed either by steep cuttings, or tunnels, or both; as for example, from near Croydon to Merstham, by the South-Eastern; from near Basingstoke to beyond Winchester, by the South-Western; from Maidenhead to beyond Wallingford, by the Great Western; and from beyond Watford to near Ivinghoe, by the Birmingham line.

After passing through the Chalk, and over the marls and sandstone strata of the Cretaceous formation, the Oolitic group, (consisting of Portland stone, Kimmeridge clay, &c.), the Lias, New Red or Triassic, and Carboniferous deposits, successively appear on the lines of railroad; excepting on those of the South-Eastern, which, upon leaving the Chalk formation, traverse the fluviatile beds of the Wealden, as we shall hereafter more particularly describe.

## EXCURSION TO THE ISLE OF SHEPPEY.

Every one knows that Sheppey is a small island about ten miles in length, lying at the mouth of the Thames, at the distance of between forty and fifty miles east from London; but every one does not know that the Isle of Sheppey is an inexhaustible mine of fossil treasures; and that from its cliffs, and on its shores, may be gathered innumerable relics of tropical plants, of birds, serpents, turtles, fishes, crabs, lobsters, shells, &c. the greater part belonging to species that now no longer exist.

A visit to the town of Queenborough, when a boy, afforded me the first opportunity of beholding fossil remains in such a state of preservation, and in such profusion, as to excite in my mind an uncontrollable desire to investigate the nature and origin of objects, which I had been taught to believe were either produced spontaneously in the earth, or were left in their present situations by the waters of a universal deluge. At a short distance from the inn where we sojourned, was a vitriol manufactory, and considerable plots of ground were covered with the pyritous clay, obtained from the neighbourhood. To my great astonishment, I perceived that these layers of earth were almost wholly made up of stems, twigs, and fragments of wood, with innumerable fruits, seed-vessels, and berries, of kinds altogether unknown to me. These fossils were of a dark colour, some quite black, very heavy, and permeated with the mineral substance termed sulphuret of iron, or pyrites. Many were so brittle as to fall to pieces upon being handled, but others were of a stony hardness, and I quickly filled a handkerchief with my newly discovered treasures, and hastened home to examine them at leisure. They consisted of the usual kinds of fossil fruits so abundant in the island (see *Lign.* 42 and 43, p. 178.), with casts of shells, and a few claws of crabs, and teeth of fishes.

Most of the specimens fell to pieces in the course of three or four months, but a few were durable, and these still occupy a corner in my cabinet as precious mementos of my juvenile researches. Many years afterwards I revisited Sheppey, and made a large collection of its fossils, which is now in the British Museum. Of late years, the increasing taste for Palæontology has brought numerous visitors to the island, which steam navigation has now placed within a few hours distance of the metropolis; and the demand for choice fossils has given rise to several local dealers. The student may, with but little trouble or expense, visit the island, make himself familiar with its geological character, and return laden with the fruits of the ancient spice islands, of whose ruins this mass of clay, in the embouchure of the Thames, is almost wholly composed. As it is some years since I last visited this interesting spot, I have obtained, as a Cicerone for the reader, the most indefatigable and successful investigator of its fossil Flora, MR. BOWERBANK; and as the courtesy of this gentleman is equal to his intelligence and scientific attainments, the traveller will have no reason to regret the absence of the author. A trip from London to Sheppey and back, affording time to procure a good collection of fossils, may be easily accomplished in three days.

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## EXCURSION TO THE ISLE OF SHEPPEY, BY J. S. BOWERBANK, ESQ., F.R.S.*

"The best conveyance is by the Southend and Sheerness steam-packets, which leave London-bridge on Tuesdays, Thursdays, and Saturdays, at 11 o'clock in the morning, and reach Sheerness about 4 or 5 o'clock in the afternoon. The town is divided into two parts,—the one contained within the limits of the garrison being designated the Blue-town, while that beyond the fortifications to the north-east is designated the Mile-town; and it is to this portion that I should recommend the visitor to proceed, and take up his quarters either at the Royal Hotel, or at the Wellington: the latter is an exceedingly snug and comfortable house, and to which I have resorted for many years. After having established himself in the inn, he should

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* Abridged from the Annals of Philosophy, by permission of the author.

request the attendance of Mr. Hays, (better known perhaps by the name of *Paddy Hays*,) from whom he may purchase, at a reasonable rate, some good fossils, such as crabs, lobsters, heads and portions of fishes, and numerous species of fossil fruits. Our traveller will then have accomplished all that can be done towards the acquisition of fossils until the following morning; there not being, I believe, any other collector in the town from whom purchases can be made.

"On the following morning an early breakfast is desirable, as a considerable extent of ground is to be traversed. It is advisable to go provided with five or six sheets of soft paper, to wrap fragile specimens in; and a few cotton or linen bags, of about four or five inches in diameter, to separate the large from the small fossils; the whole to be carried in a good-sized blue bag, or haversack; a chisel and light hammer are the only instruments required. If the geologist has a desire to view the great section of the London Clay, afforded by the cliffs on the north shore of Sheppey, and is content with the comparatively few fossils which he may be able to procure by his own exertions, he may proceed in the following manner.—Leaving Sheerness by the new town, he will pass along the sea-wall, towards Minster, until he reaches Scaps-gate, where the cliffs begin to rise from the low lands of the western end of Sheppey. A few cottages are scattered round this point, some of the inhabitants of which work upon the beach, collecting either cement-stone or *pyrites*, the latter being better known by the name of *copperas*. To these application should be made for "curiosities," and very frequently excellent specimens, and at a small price, may be thus procured. From this point the route will be under the cliffs upon the shingle, amidst which, dark patches, ten or fifteen yards in length, will be observed, composed of nodules of *pyrites*, intermixed with pyritized fragments of branches of trees, in great abundance. It is at such spots that the numerous and beautiful specimens of fossil fruits are found; but, to ensure success, the collector must be content to go upon his knees, and carefully search among the fragments. The whole of the beach, from about the parallel of Minster church to Warden Point, abounds with these patches of *pyrites;* and I have by this means obtained in the course of a morning upwards of one hundred fine fruits of various sizes. Care must be taken in such an investigation of the coast, that it be undertaken *during the falling of the tide*, or unpleasant consequences may arise from being shut in between the banks of mud which are projected into the sea at many points of the coast.

"If the principal object be the attainment of the greatest quantity of fossils, a different course should be pursued. The collector should then, after having made his purchases at Scaps-gate, direct his steps towards Minster church, passing which, he will proceed on the road towards Warden. About three-quarters of a mile beyond the church there is a lane on the left hand, leading towards the Royal Oak, in which lives a woman named Mummery, and several others, who work upon the beach, and from whom fossils are frequently to be procured. These people will direct him to the cottage of a family named Crockford, who have usually a good assortment of fossils; and to many other parties who also work upon the beach, and reside between this point and Hensbrook, to which place he must now direct his steps. At Hensbrook inquiry should be made for a man named Pead, who has generally a considerable number of good specimens in his possession. From this point (Hensbrook) the collector must proceed along the top of the cliff towards Warden, calling at the various cottages in his way, until he arrives at Warden Point, at which place he must inquire for Mud-row, many of the inhabitants of which work upon the beach, and from whom a considerable addition to the specimens already collected may be purchased. Beyond this point nothing will be obtained, and the best way to return to Sheerness, is by the road which runs through the most level portion of the country; the path along the north cliff undulates very considerably more than the road.

"The course of proceeding thus sketched applies to the supposition that the time is limited to three days, but if a longer period can be spared, I should recommend the tourist not to leave Sheerness without viewing the dock-yard; and the return to London may be made by the way of Chatham and Gravesend, affording the gratification of a view of the dock-yard and lines at Chatham, and of the fine old cathedral and castle at Rochester; at the same time, enabling him to arrive in London on the evening of the day that he quits Sheerness."

If the student's time will permit, a day or two may be profitably spent at Herne Bay on his return; and search should be made for fossils under Swale Cliff and Studd Hill, where numerous fruits and some unique mammalian remains have been found by William Richardson, Esq. (see p. 835.). Should he land at Gravesend, as recommended by Mr. Bowerbank, he should proceed towards the lime-kilns which lie on the right hand of the pier, on the banks of the Thames. To the left of the limekilns he will perceive a road leading by some bold chalk cliffs to the high ground above Gravesend; and on the right hand there is a row of cottages, or rather huts, inhabited by the labourers that work in the quarries and kilns. Many of the usual fossils of the Kentish Chalk may be obtained of the women or children in these huts; and sometimes *Cidares*, or turban Echinites (p. 346.), with spines; and Star-fish (p. 335.). A visit to the chalk-pits at Purfleet, on the opposite side of the river, is very desirable; many interesting fossils having been found in that locality. The Kentish Chalk in this district is much softer than that of Sussex, and the fossils may be easily cleared with a strong penknife; care should be taken not to wash them roughly, as they will readily separate from the chalk.

The fossils procured from the Isle of Sheppey, by such an excursion, will probably consist of portions of stems and branches of trees, and fragments of wood, perforated by Teredines (see p. 406.); specimens of the fruits of palms, resembling the recent *Nipas* of the Moluccas (p. 180.), and of plants allied to the Cucumber, Bean, Cypress, Laburnum, &c. (p. 177.); claws and fragments of the shields of Crabs (p. 530.); portions of the carapaces of Turtles (p. 770.); teeth of Sharks (p. 621.), and of Rays (p. 630.); and several species of the usual shells of the London Clay (p. 421.), and a specimen or two of Nautilus (p. 482.).

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## NOTES FOR AN EXCURSION TO BRACKLESHAM BAY, ON THE WESTERN COAST OF SUSSEX.

The line of low cliffs, extending from Selsea Bill to the mouth of Chichester Harbour, exhibits a section of the London Clay, varying in height from five or six feet to ten or twelve; it is covered at its base by a bed of shingle, fifteen or twenty yards wide, that extends towards the sea. The space between the termination of the shingle, and the limit of low-water mark, is occupied by a bed of dark grey and greenish sand; and at certain seasons, numberless specimens of the fossil shells common in the eocene strata of the London and Paris basins, are thickly spread over this arca.

Mr. Webster first directed attention to this locality, in his celebrated Memoir on the Tertiary Strata of England (see *Wond.* p. 214.); and my friend, the late John Hawkins, Esq. of Bignor Park, followed up the inquiry. In 1821 I made a fine collection of the Bracklesham fossils, and published a list of them in *Foss. South D.* and *Geol. S. E.* Messrs. Bowerbank, Saull, Dixon, Coombe, &c. have subsequently made considerable and important additions to the catalogue; and besides many new species of shells, the vertebræ and other bones of Turtles, Serpents, and Crocodiles, have been discovered. An excellent notice of this locality, from the pen of Mr. Bowerbank, appeared in *Mag. Nat. Hist.* (1840); and I am indebted to the kindness of the author for the following notes for the guidance of my readers.

"The part of the bay most interesting to the geologist, is that immediately in the neighbourhood of Bracklesham Barn, especially at about a furlong to the east of that spot, where there is a small break or chine in the low clay cliff. At this place, and at a few paces east and west of it, beneath about six or seven feet of clay, there is a stratum of light green marly sand, abounding in remains of *Venericardia planicosta*, and other shells, but which is often entirely hidden by thrown-up shingle, and it is very rarely that more than a few feet in length of this bed can be seen. It is from this bed, or from one exceedingly like it, somewhat lower in the series, that perhaps most of the interesting shells of this district are to be procured. If we proceed from this little break or chine westward, for about forty paces parallel to the coast, and then in the direction of a line at right angle to the cliff, and at the time of low water, we shall find, near the low-water-mark, the bed we have described as abounding in fossils, exposed by the action of the sea in the most favourable manner. At this spot *Venericardia planicosta* is found literally by thousands, with the valves united, the shells resting upon their edges, and packed close to each other, exactly in the manner that we might expect to have found them, supposing them to have been recent shells with the animals yet inhabiting them. Comparatively very few are gaping, and their condition and position strikingly impress upon the mind the idea that, when alive, they must have inhabited the spot from which they are now disinterred; especially as there are numerous small and fragile species of other well-known London Clay shells, which could not have remained whole had they been subjected to much attrition amid the larger shells surrounding them. On the sands in the vicinity of this spot, I found large masses of *Nummularia lævigata* cemented together, and numerous detached specimens of the same shell.

"At the eastern extremity of this bed, which, at the time of my visit, was opened for about fifty yards, I found *Sanguinolaria Hollowasii*, a rare and fragile, but very beautiful shell, in a fine state of preservation. At about twenty or thirty yards westward of the western end of this interesting patch of shells, there are large blocks of this bed, which, being of a firmer texture than the surrounding parts of the deposit, have suffered less from the action of the water, and project about twelve or eighteen inches above the surrounding sand, and, by presenting an obstruction to the ebbing tide, they usually induce the formation of a small pool amidst which they stand. At the south-eastern side of this pool, on one occasion I found the stratum, which is usually covered by the sand, completely exposed. At this spot there was scarcely a specimen of *Venericardia planicosta* to be seen, but instead of this shell, *Turritella conoidea* and *edita* were embedded in a dark green marly sand; and among them, together with *Fusus longævus*, and other well-known London Clay shells, I found *Venericardia acuticostata* and *mitis*, and a splendid specimen of *Conus deperditus*, fully equal in size to the one figured by Deshayes. Westward of this point I did not meet with anything particularly interesting.

"About midway between Bracklesham Barn and the Thorny coast-guard station, a series of patches of a deposit of chalk-flints was exposed; the first of these was nearly at low-water-mark, and the remainder of them ran, at short distances from each other, in a diagonal line towards the coast, nearly in the direction of a straight line drawn from their western extremity to the Thorney station-houses. Apparently, this stratum of flints has not, at any time, exceeded eight inches or a foot in thickness; they are, indeed, so thinly scattered, as rarely to occur piled upon each other: very few of them have suffered from attrition, and the greater part retain their original form and whitened surface. They are imbedded in the same light green marly sand, which I before described as occurring at the bottom of the London Clay, in the neighbourhood of the little chine near Bracklesham Barn. Amongst the flints there are numerous remains of the roots of trees, in the state of soft bog-wood; which indicate that this portion of the strata has been very thinly covered by the superimposed clay.

"Upon one of the bouldered flints, firmly imbedded in the marly sand, I found the most interesting of the valuable series of fossils which I had the good fortune to obtain during this excursion, namely, a fine specimen of *Astrea** attached to the upper and exposed surface of a flint."

* *Astrea*, a species of coral; see p. 299.

As to the accommodation that may now be procured near this interesting geological locality, Mr. Bowerbank informs me, that homely fare can be obtained at the little inn at Bracklesham, but there is only one spare bed. At Selsea, about six miles distant, there is a much better Inn.

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## NOTES FOR AN EXCURSION TO THE TERTIARY STRATA OF THE ISLE OF WIGHT.

Land at Cowes; examine the blocks of fresh-water limestone, along the shore, which abound in shells. Drive to Alum Bay (*Wond.* p. 224.), taking Calbourn in your route, where there are quarries of the fresh-water limestone, with innumerable casts of Paludina, Helix, Bulimus, &c. Put up at Groves' Hotel, on the summit of the hill, commanding a glorious view of Alum Bay, with the Hampshire coast, and the Isle of Purbeck on the right, and Portland Island looming in the remote distance; and on the left, the vertical cliffs of chalk, and the Needles. The pathway that leads down to the sea-shore traverses a chasm, separating Headon-hill on the right, from Alum Bay on the left; in the former, fresh-water shells—in the vertical beds of clay, in the latter, marine shells—may be obtained in great abundance and variety (see *Wond.* p. 228.).

If you land at Ryde, the small quarries at Binstead are worthy constant research, for the chance of mammalian remains (see p. 835.).

The following extract from the splendid work of Sir Henry Englefield on the Isle of Wight, describes certain geological changes still in progress on the shore near Ryde, that are well deserving the visitor's attention.

"A great and very singular change has taken place within no very distant period of time on the shores of the Solent, near to Ryde; and which seems to be still sensibly proceeding. When Fielding, in the year 1753, was at Ryde, on his voyage to Lisbon, he describes the town as totally inaccessible by sea, except at or near high water; as the tide, on its recess, left a vast extent of mud, too soft to bear the lightest weight. This mud-bank is now entirely covered by a stratum of fine white sand, smooth and firm enough to bear wheel-carriages, and which renders the bathing at all times safe and agreeable. This bed of sand now reaches to Binstead, having covered at least two miles of the shore within the last half century; and the inhabitants say that it is still extending to the westward. On digging through the sand, the old mud presently appears, the sand stratum being very thin. To what cause this change is owing it is difficult to guess; but it is an example of the alternation of deposits from the action of the sea, in circumstances apparently unchanged, which may afford cause for reflection to the geologist." *

If the visitor have leisure, he should make a tour of this interesting island, from Ryde to Shanklin and Ventnor, along the beautiful scenery of the Under Cliff, formed by the slips of the Shanklin Sand; to Black Gang Chine, and Fresh-water Bay; visiting Brook Point (*Wond.* p. 358.) to collect fossils from the Wealden strata on the sea-shore.

* Sir H. Englefield's Isle of Wight, p. 16.

# CHAPTER XXIII.

## NOTES FOR A GEOLOGICAL EXCURSION, OVER THE CHALK AND WEALDEN FORMATIONS OF THE SOUTH-EAST OF ENGLAND, FROM LONDON TO BRIGHTON; AND FROM BRIGHTON TO ROTTINGDEAN.

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NOTWITHSTANDING the benefit conferred on the geologist by the railways, in the rapid transit they afford to distant interesting localities, this new locomotive power has many attendant disadvantages; and the lover of rural scenery, and the traveller who wishes to examine in detail the physical features of our island, will often have cause to regret the loss of our excellent coaches, and still more, the clean little Inns in our country towns and villages, in which the geological tourist always found a welcome reception, and a comfortable home.* My

* Even in the route from London to Brighton, the change in this respect is lamentable. During the last summer I was desirous of visiting some of the scenes of my early researches; and upon several occasions found the Inns at which myself

notes therefore must, in a great measure, be restricted to the railway sections.

In travelling from London to Brighton by the railway, the following geological features of the country may be observed; by a reference to *Wond.* p. 340, and to the coloured section, *Wond.* Vol. II. Pl. IX. the structure of this remarkable district may be easily understood.

Leaving the station at London Bridge, the *London Clay*, with its characteristic fossils, is seen beyond Deptford, by New Cross, Sydenham, &c.; and approaching Croydon, beds of gravel appear, with interspersions of olive-green sand. These strata belong to the Eocene formation, and lie above and upon the Chalk. The valley beyond Croydon (Smitham Bottom), along the side of which the railroad is carried, is composed of gravel resting on chalk; beyond the station called *Stoat's Nest*, there is a fine section of the chalk, with layers of flint, and two parallel seams of marl, at the distance of six or eight feet from each other. These extend, with but little interruption, several miles, preserving their parallelism, although the strata in many places have

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and scientific friends had formerly sojourned, either shut up altogether, or converted into beer-shops; and at the close of the day, I had to proceed some eight or ten miles before a night's lodging could be procured. Should the reader be induced to visit any of the places described in these volumes, that are at a distance from the railways, it will be necessary for him previously to ascertain what accommodation is within reach.

sustained considerable disturbance. The tunnel through the Surrey chalk hills is now entered, and its transit occupies three minutes and a half. At Merstham the chalk, marl, and firestone, are intersected, and the Shanklin sand of Red Hill appears; and from thence to Horley station, the lower sands and clays of the Chalk formation are passed over or cut through; affording sections of sandstone, ironstone, and fuller's earth.

All the strata we have hitherto traversed are of marine origin, and contain fossil shells, fishes, crustacea, &c., and remains of other inhabitants of former oceans. But we now enter upon the series of river deposits which form the Wealden, and contain only the relics of terrestrial or fresh-water animals and plants.

At Horley the weald clay appears, and is succeeded by sand, sandstone, and shale, to Crawley. Passing through the tunnel of the Wealden strata, we arrive at Balcombe, where sandstone in laminæ and in thick beds, having the surface at the lines of junction covered with ripple marks, is seen on each side the railroad; the dip of the strata is to the *north-east*. After crossing the deep valley at Balcombe, over the magnificent viaduct, the line runs along alternations of sand and clay, dipping *south-west;* we have thus passed over what is termed the anticlinal axis of the Wealden (*Wond.* p. 342.). Arriving at Hayward's Heath station, the tunnel exposes a good section of the Wealden sand, sandstone, shale, and blue marl or oak-tree clay, to a depth of about thirty-six yards. The strata are disposed in the same order and thickness as in the quarries around Cuckfield; namely, fawn-coloured sand and sandstone, like those of Little Horsted, with beds of calciferous grit or Tilgate stone; and beneath, layers of the blue clay. The strata are very barren in organic remains; several hours' research only afforded imperfect vegetable relics, such as comminuted stems and leaves of the various species of ferns, which occur in Tilgate Forest (see *Wond.* p. 370.). Some of the grey laminated sandstones and shales at this place very closely resemble certain strata of the Coal measures.

Proceeding over the Weald clay with the Sussex marble of St. John's Common, the line encounters the Shanklin sand of Sussex, at Stone-pound gate. Here then we quit the fresh-water strata of the Wealden, and again enter upon the marine deposits of the Chalk formation. At the foot of the northern escarpment of the Southdowns, the Chalk is penetrated at the base of Clayton Hill, the tunnel running through the lower members of the Chalk—the Galt and Chalk-marl—and emerging at Piecombe through the White Chalk; from thence to Brighton, the sections and tunnels intersect or perforate the same cretaceous deposits.

By a reference to the section, *Wond.* Pl. IX., it will be seen that the various strata cut through, are repeated on the north and south of a line drawn from east to west through the Forest Ridge. Thus, the railroad has to pass through two ranges of chalk hills by tunnels—those of Merstham and Clayton; two principal ridges of Wealden strata—at Balcombe and Hayward's Heath; and the Shanklin sand at Red Hill, in Surrey, and near Hurstperpoint, in Sussex. There is no railroad in the kingdom that, in the distance of fifty miles, exhibits geological phenomena of greater variety or interest.

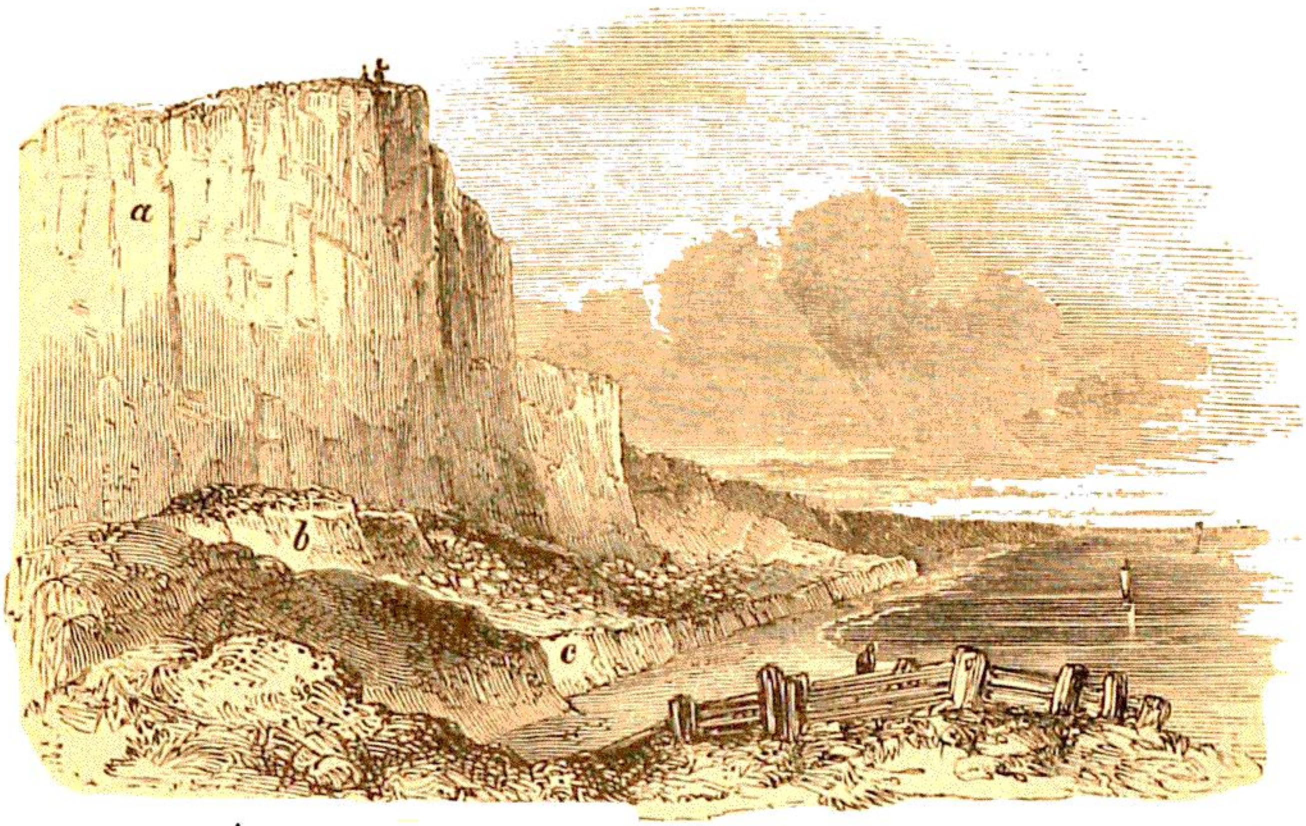
If the student will refer to *Wond.* p. 342, the stratification above pointed out, will be better comprehended. The sections visible on the turnpike road from London to Brighton are described, *Wond.* p. 343.

The neighbourhood of Balcombe station will afford some sections of easy access; and from Hayward's Heath station, Cuckfield is about two miles distant. The quarries on the hill above that town were formerly very productive, and the usual Wealden fossils may still be obtained; namely, casts of several species of fresh-water shells (*Wond.* p. 377.); scales and teeth of fishes (*Lepidotus*, p. 638.); bones of reptiles; and vegetable remains.

## GEOLOGICAL STRUCTURE OF BRIGHTON CLIFFS.

" Yes! where the huntsman winds his matin horn,
And the couch'd hare beneath the covert trembles;
Where shepherds tend their flocks, and grows the corn;
Where Fashion on our gay Parade assembles—
Wild Horses, Deer, and Elephants have strayed,
Treading beneath their feet old Ocean's races."

HORACE SMITH.




*G. A. M. del*[t.] 1836. *J. Whimper, lign*[t.]

LIGN. 159. BRIGHTON CLIFFS, from the Sea-shore, near KEMPTOWN; looking East, or towards Rottingdean.

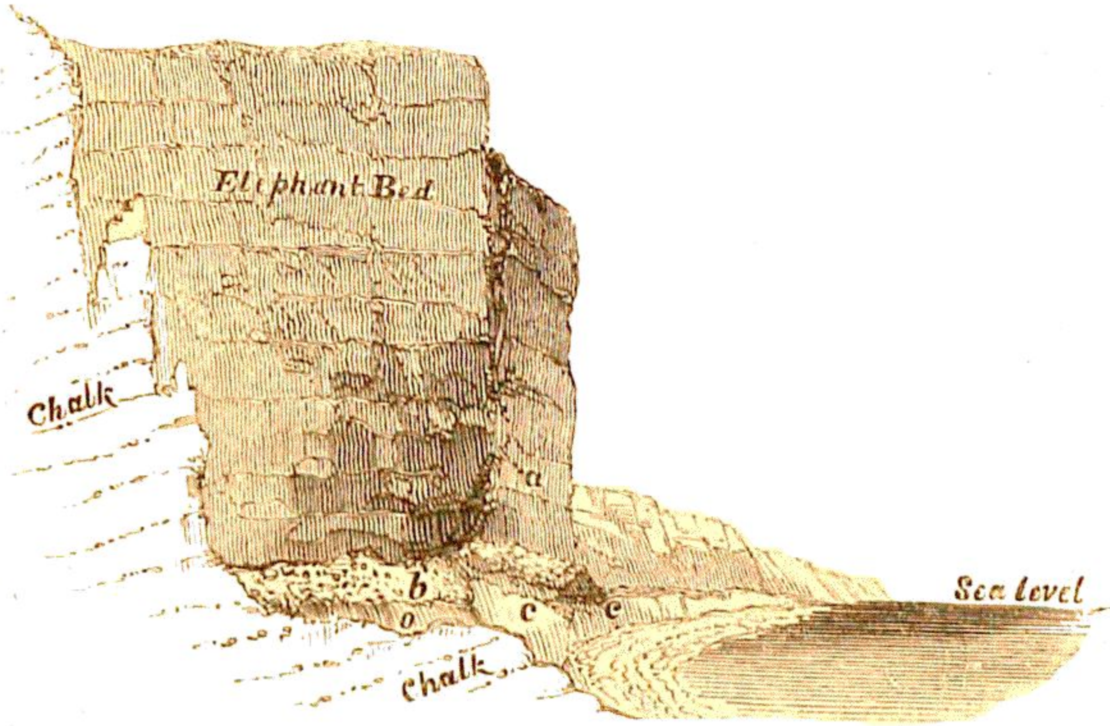
*a.*—The Elephant bed.
*b.*—An Ancient Sea-beach, composed of shingle and boulders of granite, porphyry, &c.
*c.*—The Chalk which forms the base of the cliff.

A stroll from Kemptown, along the sea-shore to Rottingdean, is replete with interest, for the strata of which the cliffs are composed, clearly demonstrate that, in very remote periods, great changes have taken place in the relative position of the sea and land along the Sussex coast.

Some years since, the bare face of the Cliffs, from the entrance to the esplanade of the Chain-pier, at the Old Steyne, to Kemptown, was completely exposed, and presented a most interesting section of the strata. But at the present time, as every one knows, no portion of the cliffs is visible west of the *groin* below Kemptown; and the sections, in my first work (*Foss. South D.* Pl. IV. and V.), are the only records of the appearances formerly presented, and now concealed by the sea-wall. Even the cliffs immediately beyond Kemptown, are rapidly diminishing, from the action of the waves, which dash with greater violence against their base, in consequence of the means taken to protect the adjoining terraces from the encroachments of the sea.

The appearance of the Cliffs east of Kemptown is shown in the sketch, *Lign.* 159. But further along the shore, towards Rottingdean, in a ravine excavated by the encroachments of the sea, the ancient chalk cliff behind the mass of strata seen above, is exposed; this is represented in *Lign.* 160. A description of the appearances at this point will elucidate the nature of the strata of which these cliffs are composed.

Upon examining the shore at low-water, masses of chalk, covered with fuci (*sea-weed*), &c. are seen protruding through the sands; and towards the base of the cliff, a bed of sea-beach is spread upon the




*G. A. M. del<sup></sup>.* 1836 — *J. Whimper, lign<sup></sup>.*

LIGN. 160. CLIFFS BETWEEN KEMPTOWN AND ROTTINGDEAN: seen from the West.

*a.*—ELEPHANT-BED; calcareous strata, containing teeth and bones of Elephants.

*b.*—ANCIENT SHINGLE, or sea-beach.

*o.*—BED OF SAND; containing bones of Whales, and marine shells.

*c, c.*—Strata of undisturbed CHALK, dipping towards the Downs.

sand; a low wall, or terrace, of white chalk, constitutes the boundary of this shingle, as seen in *Lign.* 159, *c.* Thus we perceive, that the present shore is formed by the continuation of the chalk strata of the neighbouring Downs, partially covered with sand and beach; which are the detritus of the flints that have been washed out of previously existing layers of chalk, and ground down by the action of the waves. Now, along the eastern part of the coast, towards Rottingdean and Newhaven, the chalk rises into mural precipices immediately from the sea-shore; but at this place the cliffs are composed of very different materials.

1. In the first place, there is, lying immediately on the terrace of chalk that forms the boundary-wall of the base of the cliff (*Lign.* 159, *c*, and *Lign.* 160, *c*, *c*,) a bed of sand (denoted by the letter *o*, *Lign.* 160.), of irregular thickness and variable extent; from this sand, marine shells, and the jaw of a Whale (see p. 824.), have been obtained.

2. Upon the sand is a bed of loose shingle—a regular sea-beach—appearing in no respect different, to the common observer, from that forming at the foot of the cliffs at the present moment; this bed is marked *b*, in *Lign.* 159, and 160. Upon examining this shingle, it is found to contain numerous pebbles and boulders of granite, porphyry, sienite, and other plutonic rocks (see p. 46.), none of which occur in the present beach. And in this ancient shingle, teeth and bones of extinct species of Elephant, Horse, and Deer, have been discovered. We have here, then, unquestionable evidence that this beach has been formed under conditions altogether different from those which now prevail; for not

only is this shingle-bed elevated above the present sea-level, but its contents are of such a nature as could not have been thrown up by the sea, in its present relation to the countries that form its shores.

3. A series of loosely aggregated calcareous deposits, obscurely stratified, rests upon this bed of shingle, and forms the upper portion of the cliff, varying in total thickness from fifty to one hundred and twenty feet. These strata are composed of chalk rubble and loam, with flints partially water-worn, and boulders, and pebbles of tertiary sandstone; the whole promiscuously intermingled, and deposited in nearly horizontal layers, from one to three or four feet thick. But the face of the cliff generally presents a weather-worn and crumbling aspect, and large masses are constantly falling down, in consequence of the removal of the ancient shingle, by the effects of the waves at the spring-tides. From the loose state of aggregation of these beds, the fallen masses are speedily washed away, but here and there blocks of great hardness, provincially termed *Coombe-rock*, remain upon the shore; and, but a few years since, there was a group of high rocks of this kind near the Chain-pier. This compact conglomerate has been produced simply by an infiltration of calcareous spar (see p. 52, and *Wond.* p. 65.), which has cemented together the fragments of chalk, flint, &c. In some places, this infiltration has reached the bed of ancient shingle below, and large blocks are occa-

sionally found, consisting of pebbles of flint, granite, &c. held together by veins of calc-spar, in acicular, or needle-like crystals. In these sparry conglomerates, the teeth and bones of the mammalia previously noticed are sometimes found.*

It is in this accumulation of calcareous strata that numerous bones and teeth of the Mammoth, or fossil Elephant, have been discovered; I have therefore designated it, the *Elephant-bed;* to distinguish it from other loose calcareous deposits.

As seen immediately beyond Kemptown (*Lign.* 159.), the cliffs appear to be entirely composed of the materials above described; but farther on, the face of the ancient chalk-cliff is exposed (see *Lign.* 160.); and if we extend our walk to Rottingdean, we find in many places the Chalk alone forming the present cliff; the Elephant-bed, and its associated shingle and sand, having been swept away. A like destruction awaits the remainder of these interesting deposits at no very distant period.†

After collecting specimens of the Elephant-bed, both of the friable varieties, and of the coombe-rock, and a few of the pebbles of granite, porphyry, &c. from the ancient beach; and also some of the sand

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* My daughter discovered part of the lower-jaw of a Deer, with teeth, imbedded in this conglomerate, in a mass on the shore near Rottingdean.

† See Foss. South D. p. 277, Pl. IV.; and Geol. S. E. p. 30; Wond. pp. 100—104.

beneath the shingle, to examine microscopically on our return home, let us sit down on this mass of fallen chalk, and consider the nature of those changes in the relative position of the land and sea, which the phenomena before us appear to indicate.

We have seen that these cliffs are composed of the following deposits:—1. The Elephant-bed (*Lign.* 159 and 160, *a.*); a series of calcareous strata, with bones and teeth of Elephants, Horses, Deer, and Oxen. 2. An ancient sea-beach (*b.*), with pebbles and boulders of plutonic rocks, and bones of mammalia; and a bed of sand beneath, in which cetacea and mollusca (apparently of existing species), have been found. 3. Lastly, the regular Chalk-strata (*Lign.* 160, *c*, *c.*), extending far out to sea.

These appearances demonstrate the following sequence of physical changes, namely—

1stly. The Chalk terrace (*c*, *c.*), on which the ancient shingle-bed (*b.*) rests, was on a level with the sea for a long period; for this beach must have been formed, like the modern, by the action of the waves on the then existing chalk cliffs (see *Lign.* 160, *Chalk*). But there must have been some cause in operation, by which pebbles and boulders of granite, porphyry, and other rocks, foreign to our shores, and bones of Elephants, &c. were thrown up on the strand, and imbedded in the beach then in the progress of formation. These transported materials may have been floated to the Sussex coast by icebergs; an agency by which the delicate bones and teeth might be deposited without injury, although surrounded by the water-worn detritus (see p. 54.).

2dly. The whole line of coast, with the ancient shingle, must have subsided to such a depth, as to have allowed of the deposition of the calcareous strata, forming the Elephant-bed. And from the absence of gravel and beach, and the circumstance of the chalk-rubble, of which they are largely composed, often presenting angular fragments, it would appear that this deposition took place in some tranquil bay or inland sea.

Lastly. The land was elevated to its present level; and at this period the formation of the existing sea-beach and line of cliffs commenced.

The reader must not conclude, from our remarks being restricted to the cliffs before us, that the phenomena here contemplated were limited to this district; on the contrary, if our space would permit, it might be shown that they are referable to extensive geological changes, which took place in the period immediately antecedent to the present. In all the valleys of the South-east and East of England that open into the sea, traces, more or less extensive and important, of similar deposits exist. The level plain called the *Steyne*, at Brighton, is entirely formed of the Elephant-bed, which extends up the valley to Preston and Patcham; in the latter place, bones and teeth of Elephants have been found. At Southbourn, the plain at the foot of the Chalk hills, called "*The Wish*," containing remains of the Elephant, rhinoceros, and hippopotamus, evidently belongs to the same epoch. At Folkstone, Mr. H. Carr discovered large blocks of *Coombe rock;* and at Dover, above the Chalk, similar masses occur. On the opposite coast of France there are also indications of these deposits. All these phenomena are no doubt connected with the occurrence of immense quantities of mammalian remains in the superficial loam, &c., on the eastern coasts of England, and are referable to the same geological epoch.

Imbedded in the Chalk, which is exposed at low water along the shore, very large Ammonites may sometimes be found between Kemptown and Rottingdean;* and numerous examples of fossil sponges and other amorphozoa (p. 252.).

The teeth and bones of mammalia are rare in these cliffs, and it is not probable that any will be obtained in a first visit; but from the fishermen and boys seen strolling along the shore, specimens may often be purchased.

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* One of the largest specimens in my collection, was obtained from this coast, and presented to me by Horace Smith, and M. Ricardo, Esqrs.

# CHAPTER XXIV.

## GEOLOGICAL NOTES OF VARIOUS PLACES ON THE LINE OF THE GREAT WESTERN RAILROAD, FROM LONDON TO CLIFTON.

THAT splendid railway, the Great Western, by which the geologist may be transported in five or six hours, from the Tertiary strata of the metropolis, to the magnificent cliffs of Mountain limestone at Clifton, exposes in its course several fine sections, and passes within a moderate distance of some interesting localities of organic remains.

This railroad traverses the *Tertiary* strata by Ealing, Hanwell, and Slough, entering the *Chalk* near Maidenhead, and pursuing rather a circuitous route to Wallingford, beyond which station it passes over the *Oolite*, and displays some bold sections of the limestones and clays of that formation. Near Bath it emerges on the *Lias*, and crossing a narrow belt of the *New Red*, passes on to the *Carboniferous* strata of the Bristol coal measures.* In this route, there are four places particularly deserving a visit from the geological student, and collector of

* See Prof. Phillips's or Mr. Woodward's Geological Map.

organic remains, namely, Faringdon, Swindon, Calne, and Chippenham.

VISIT TO FARINGDON.—The railway station is reached in from two, to two and a half hours from London; and an omnibus meets the morning and evening trains, to convey passengers to the town of Faringdon, which is about four miles distant.* There are two Inns in the town, the Crown, and the Bell, where comfortable accommodation may be obtained.

The town is situated in a valley, between Faringdon Hill, an eminence seen from a considerable distance in the approach from Oxford, and Badbury Hill (see *Lign.* 161.). A small stream divides the town into two tithings, called Port, and West-port, and flows into the Thames on the north. The summits of the highest eminences near Faringdon consist of beds of the lower Green or Shanklin sand, which rest upon strata of Coral-rag; and there is a ridge of Shanklin-sand that extends by Coxwell furze-hills, towards the Chalk downs on the south; being succeeded by the *Galt*, *Chalk-marl*, and *Chalk*; as shown in the section, *Lign.* 161.

FOSSILS OF THE SHANKLIN SAND.—I have not observed any organic remains in the strata on the

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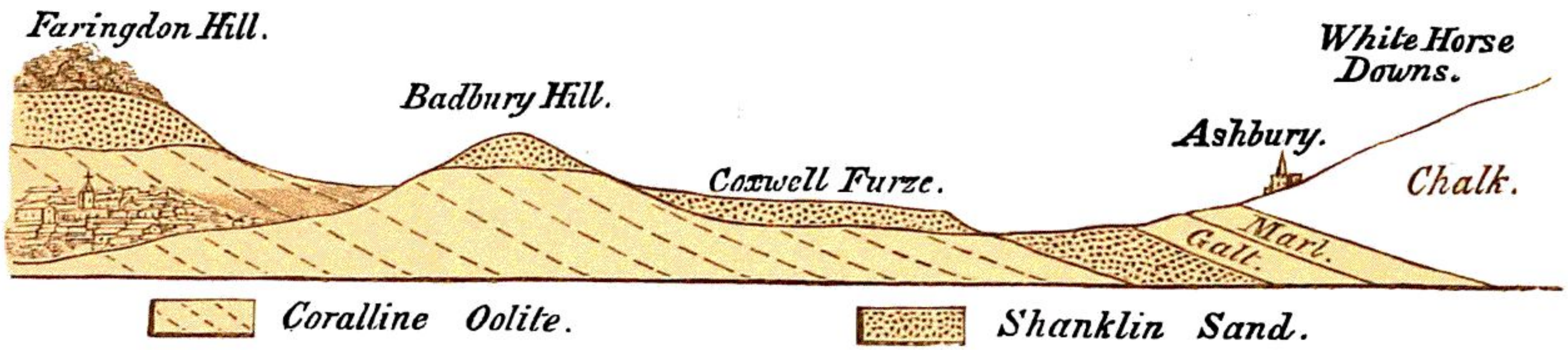
* As there is not a conveyance from Faringdon to meet every train that stops at the station, the visitor who objects to a long walk, should previously ascertain the time when the omnibus or coach does arrive, and select a train accordingly.




LIGN. 161. SECTION OF THE STRATA AT FARINGDON, BERKS; from FARINGDON HILL, to the CHALK DOWNS on the South.

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The summits of Faringdon and Badbury Hills, are formed of outliers of the Shanklin Sand. The lines on the Coralline Oolite are not intended to denote the dip of the strata.

top of Faringdon and Badbury Hills, but from the pits in the low country, numerous fossil sponges, and other *amorphozoa* (see p. 256.), may be obtained. One of the most productive "gravel-pits," as they are here termed, is situated on the road to Little Coxwell, about three quarters of a mile from Faringdon. It lies on the left of the road leading to the pretty village of Shrivenham. In this pit, the strata consist of a coarse aggregate of siliceous particles, with some lenticular masses in the state of compact conglomerate; the lower beds are of a whitish grey, the upper of a deep ferruginous colour. The Windmill public-house, close by, is kept by the owner of the pit (*Panting*), and specimens of the "petrified salt-cellars" (see p. 257.), and other sponges, may generally be obtained of the inmates; but the collector, in a few hours, will be able to gather an extensive and interesting collection; the pick-hammer, *Lign.* 158. fig. 2, will be found the most convenient instrument. There are two other pits within a moderate distance of Panting's pit, which are also rich in fossils. The principal organic remains to be obtained from these beds are the zoophytes figured p. 256, and *Wond.* p. 560. The reader should recollect that the beautiful cup-shaped sponge (*chenendopora fungiformis, Wond.* p. 561.), is the "*petrified salt-cellar*" of the quarrymen. As many specimens as possible of the interesting coral, *Verticellipora* (p. 289, *Lign.* 55, fig. 4.), should be procured, to examine the internal structure at leisure. The cup-shaped sponges should be collected uncleared, for they are often full of minute corals, shells, echinital spines, &c. There are also numerous specimens to be met with of *Belemnites*, *Terebratulæ*, *Ostreæ*, and other shells of the Green Sand; and occasionally, casts of a large species of *Nautilus*, and bones of *Plesiosauri* and *Ichthyosauri*.

FOSSILS OF THE CORALLINE OOLITE.—At a short distance from the town there is a large quarry of Coral-rag, called Lamb-close-pit, from which *Cidarites* (p. 346.) and spines, and several species of corals (p. 300.), and shells may be procured. Occasionally Ammonites and Belemnites are met with in the limestone at this place.

*Stanford pit*, about three miles south-east of Faringdon, is well worthy of a visit; it consists of the following strata:—

1. Uppermost; *Coral rag*, three and a half feet.
2. Limestone, containing an abundance of shells, particularly of Trigoniæ (p. 388). &c., four and a half feet.
3. Portland sand, of an olive-green colour, three feet.
4. Kimmeridge clay.

Some shells are extremely numerous; principally of the genera *Trigonia*, *Gervillia*, *Pecten*, *Ostrea*, *Terebratula*, &c.; fine Belemnites also occur. The oolitic structure is very apparent in the upper beds of limestone.

SWINDON, WILTS.—Fourteen miles beyond the Faringdon station of the railway, we arrive at that of Swindon, where the trains stop ten minutes. About a mile from this station, on the rising ground to the south, stands the little, and formerly retired, town of SWINDON. Here, when a schoolboy, my curiosity was strongly excited by the petrified "*ram's horns*," and "*oak*," so abundant in the solid masses of stone in the neighbouring quarries, and which daily came under my notice, in my rambles around the town. It is indeed a locality most prolific in the Ammonites and other shells, and in the fossil wood peculiar to the upper division of the Oolite formation — the Portland beds; the hill on which the town is built consisting of those strata. There is a comfortable Inn, the Goddard Arms, where the traveller will meet with the requisite accommodation; and when I last visited it, the waiter had many fossils of the Kimmeridge clay, from the neighbouring valley traversed by the railroad, and also from the limestone strata, for sale. The quarries, which are in the immediate vicinity of the town, abound in Ammonites, Trigoniæ, and other shells; and some layers are entirely composed of the casts of several species. The Ammonites are principally of two kinds, viz. *A. biplex* and *A. triplicatus*, and vary in size from a few inches to two feet in diameter; the specimens are casts only, no vestiges of the shells remaining. At Aylesbury the same species occur in clay, with the shells entire (see p. 492.). A large collection may be made in a few hours; and from some of the quarrymen the less common forms may probably be obtained. Casts of the bivalves called *Gervillia*, and *Perna*, abound in the quarry on the right hand of the road. I have collected from this place, in addition to those above mentioned, casts of the genera *Buccinum*, Cardium, Cytherea or Venus, Nerita, Terebra, Pullastra, Pecten; and of the large species of *Pleurotomaria*, which occurs in the Kimmeridge clay of Hartwell, with the shell perfect (p. 426.); also vertebræ of *Ichthyosauri*.

A section of the strata from Swindon, to the nearest point of the chalk hills, would pass over, in succession,—1. Portland oolite; 2. Green sand; 3. Galt; 4. Chlorite chalk; 5. Chalk-marl; and, 6. Chalk.

CHIPPENHAM AND CALNE.—At the distance of ninety-three miles from London, the train conveys the traveller, in from three and a half to four hours, to the town of Chippenham, which is situated on the Oxford clay of the Oolite formation; a locality from which there have recently been obtained those interesting specimens of *Belemnites*, that contain vestiges of the soft bodies, and arms (see p. 469.).

CALNE, about six miles from Chippenham, stands on Oolitic limestone; and the quarries around the town have long been celebrated for the perfection and abundance of their fossil remains; particularly of various species of the turban echinites (*Cidarites*, see

p. 346.), and their spines. A day or two at each of these towns will be well spent by the geologist, and the collector of organic remains.

BATH AND BRISTOL.—The immediate vicinities of these cities are rich in interesting localities for the geologist. A visit to the public museums in Bath and Bristol cannot fail to gratify the student, and will at once point out to him the places most worthy his examination. That of Bristol, under the care of the eminent naturalist, *Mr. Stutchbury*, is admirably arranged, and contains, among other treasures, the specimen of fossil *Squaloraia* (see p. 628.); the remains of the reptiles of the magnesian conglomerate, the *Thecodontosaurus* (p. 760.); and the celebrated collection of Crinoidea formed by the late Mr. Miller (p. 314.).

CLIFTON.—The stupendous rocks of mountain limestone which flank both sides of the Avon in its course from Clifton to the Severn, are too well known to render a general description necessary, and our limits will not admit of details. The geological student should first obtain a *coup d'œil* of the appearance and position of the strata, by sailing down to the embouchure of the river in a steam-packet, and afterwards visit on foot the most interesting localities. On the right bank of the river, near the "Black Rock," the teeth of several kinds of fishes of the genera *Psammodus* (p. 617.), *Hybodus* (p. 621.), *Ceratodus* (p. 630.), &c. may be obtained; and shells and corals of the mountain limestone.

Polished specimens of the coralline marbles may be purchased at the shops.

*Portishead*, a pretty little village on the south-east bank of the Severn, is well worth a visit; and by going in the morning steamer and returning in the evening, several hours may be agreeably spent along the shore below the hotel; and fossil plants and shells, from the blocks of millstone grit, and numerous rock specimens, may be collected.

A sail to *Chepstow*, and up the Wye as far as Tintern Abbey, returning on foot, or in a carriage, by Piercefield to Chepstow, is an excursion replete with the highest interest and enjoyment. The picturesque beauties of the Wye are dependant, like those of Clifton and Matlock, on the disruptions which the strata of mountain limestone have sustained. The magnificent scenery as we pass up the river, and the interesting associations connected with the ruins of Tintern Abbey, cannot fail to delight the traveller; but the enchanting scene that bursts upon the sight from the heights of Piercefield is magnificent in the extreme, and equal to the grandest views on the Rhine. Looking down from those elevated pinnacles of rock, which are covered with the most luxuriant vegetation, and crested with forests of pine, and oak, and beech, we perceive the Wye pursuing its tortuous course at our feet, and winding along, around promontories of limestone, towards Chepstow; while immediately beyond, and apparently separated from the opposite bank of the river only by a precipitous rampart of mountain limestone, the Severn appears as a vast inland sea, bounded in the remote distance by the country around Gloucester, and extending on the right to the Bristol Channel.

Among other interesting geological sites within a few miles of Clifton and Bristol, may be mentioned—

1. Aust Cliff; a section of the Lias, from which many interesting fossils have been procured.

2. Banwell Cave; which is particularly deserving of examination (see p. 857.).

3. Cheddar Cliffs; which are equally interesting to the geologist and to the lover of picturesque scenery. They are about twenty miles from Bristol; and a carriage and pair will be required, if the visitor intends to return the same day. The best arrangement is to visit the cavern at Banwell, and remain in the neighbouring town the following night; and make an excursion to Cheddar Cliffs the next day.

There has lately been opened at Cheddar, a cavern which surpasses in the beauty of its stalactites any hitherto discovered in England. The Rev. W. D. Conybeare states, that it is the only one that at all realizes any idea we have of the far-famed *Grotto of Antiparos*. My friend, Rickman Ross, Esq., who visited it last summer, informs me that it consists of one grand arch, or porch, and three or four lateral branches and narrow fissures, about ten or twelve feet broad, and from thirty to forty feet high, vested and draped with the most fantastic hangings of stalactite. The floor is a mass of stalagmite, covering a bed of gravel of the mountain limestone, which fills up about ten feet of the bottom. I am not aware that any fossil bones have been observed.

When visiting Banwell, inquiry should be made if there be any Cave at Hutton accessible to the visitor.

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The above remarks must be regarded only as suggestions; for it would require a volume to particularize the geological objects of interest within a short distance of Bristol. The coal-mines in the neighbourhood of Bath and Bristol should be visited, and fossil plants collected.

# CHAPTER XXV.

## GEOLOGICAL EXCURSION TO MATLOCK.

———— "In famed Attica such lovely dales
Are rarely seen; nor can fair Tempè boast
A charm they know not."

LORD BYRON.

THE beautiful and romantic Dale of Matlock, although one hundred and forty-two miles distant, is now brought within nine hours of the metropolis. Leaving London from the Euston-square station of the Birmingham Railway, at eleven o'clock, (taking the precaution to have a ticket that will ensure a passage from Rugby by the *Midland* Counties Railroad to Derby), we pass over in succession the clays, sands, and beds of gravel, composing the *Tertiary* strata of the London basin; and at Watford, steep cuttings of these deposits are seen on each side of the station. A long tunnel through the *White Chalk* of Hertfordshire is then passed; and at Tring we arrive at the termination of the Chalk, and obtain a fine view of the north-west escarpment of the

Downs, which is seen extending on the right towards Ivinghoe, and attaining an elevation of 900 feet. The railway then proceeds over the Marl, Galt, and Shanklin Sand, to near Leighton, where these members of the Cretaceous system are succeeded by the *Oolite* of Buckinghamshire and Northamptonshire; and the line crosses the Grand Junction Canal, near the emergence of the *Lias;* the Rugby station being situated in the midst of that formation. We then enter the Midland Counties line, and pass on to Stoney Stanton, where the Lias terminates, and the *Triassic*, or *New Red* strata appear; proceeding towards Leicester, clays and marls of a dull red colour, denoting the Triassic deposits, constitute the slopes on each side the railway. As we approach Leicester, the craggy summits of Charnwood Forest appear in the distance on the left, with here and there an isolated conical hill, indicating the protruded masses of granite, porphyry, and sienite, which belong to the group of plutonic rocks of the central county of England.

Leaving Leicester for Derby, the route continues along Triassic strata; and a good section of the variegated marls, with veins of white fibrous gypsum, may be observed at *Red Hill*, where a short tunnel perforates a ridge of the same deposits. The railroad then emerges on the verdant alluvial plain, through which the Trent, its waters increased by the confluence of the Dove and the Soar, pursues its course towards the north, and joins the Humber at

Alkborough, whence the united streams flow on, and empty themselves into the German Ocean.

At Derby, where the train arrives at half-past five, half an hour is allowed for dinner; and we then proceed by the *North Midland* line, by Duffield, and Belper, through a beautiful valley watered by the Derwent, which is seen winding its way towards Derby. The high grounds skirting this valley are composed of the millstone-grit, and sandstone of the Carboniferous system (see p. 41.). Ten miles beyond Derby, we arrive at Amber Gate station, where an omnibus and other conveyances are in waiting, to convey passengers to Cromford and Matlock.*

The road from Amber Gate, leads through a succession of picturesque scenes of surpassing beauty. At Whatstandwell-bridge† (see *Lign.* 165.), over which the Derwent is crossed, the view is most imposing. The river is seen rapidly pursuing its course between richly wooded ravines, fringed with

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* As it frequently happens that more passengers are brought by the train, than the omnibus or coach can convey, some activity is necessary to secure an outside place, which it is most desirable for the geological tourist to possess, that he may command a good view of the splendid scenery, which will be constantly opening on his sight, through the romantic pass that leads to Matlock.

† HOTSTANWELL in the guide-books; *Whatstandwell* in the Ordnance Map.

luxuriant foliage to the water's edge.* As we advance, the bold mountain ridge of *Crich Hill* appears on the right, with the village of Holloway at a considerable elevation, and Lea Mills near the base of the range; while on the left are the hills, and overhanging woods of Alderwasley. Ascending to the Inn at Cromford, the road turns suddenly to the right, and by an opening cut through a mass of strata twenty feet thick, called *Scarthing Rock*, conducts to the southern entrance of Matlock Dale. On passing this chasm, the glorious features of this enchanting region burst on the view. On the east is a range of limestone cliffs, richly wooded, with Willersly Castle, the seat of the Arkwrights, embosomed in trees on a commanding eminence; and on the west, a rocky precipice, crested with forests, and its sides partially covered with copses and brushwood; while the river, dashing through the ravine on the right, completes the magic of the picture—

> "So wond'rous wild, the whole might seem
> The scenery of a fairy dream."
>
> LADY OF THE LAKE.

At the distance of about half a mile, we pass the toll-gate, and a bold mural precipice of mountain limestone suddenly appears on the eastern bank of the river; while on the western, a steep

* The pedestrian should alight at the little Inn at Whatstandwell; and walk on to Matlock the following morning.

slope, clothed with verdure, rises rapidly to the lofty pine-clad eminence called MASSON HILL, an elevation of upwards of 1,000 feet. The base of this mountain stretches directly across the dale in front, and apparently presents a barrier to an egress from the valley on the north; but as we advance, the road is seen to wind round its foot by a defile along the left bank of the river; and the magnificent rock, called the HIGH TOR, rises in majestic grandeur on the right. The valley now gradually expands, and at the distance of about two and a half miles from the entrance at Scarthing's rock, terminates in the campaign country beyond Matlock village.* From the precipitous nature of the escarpment of mountain limestone which forms the eastern boundary of the dale, the buildings at Matlock Bath are confined to the left or western side of the Derwent, and are scattered here and there among the trees, on the projecting plots and terraces formed by the fallen cliffs of sandstone, which, during the lapse of ages, have become partially disintegrated, and are more or less concealed by vegetable soil; the projecting rocks are covered with lichens, mosses, and ferns.

The hotels, of which there are several, are all delightfully situated; but the *Temple Hotel*, which stands on a terrace on the side of Masson Hill, about a hundred feet above the river, has the pre-

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* The proper name of the hamlet in the valley, generally called Matlock, is *Matlock Bath.*

ference in my estimation; its elevated situation, its seclusion from the noise and bustle of the village, and its bowers, and hedge-rows of sweet-briar and roses, imparting a character of sylvan beauty to the spot, peculiarly grateful to the traveller who wishes to enjoy a quiet sojourn at Matlock Dale.* The local guide-books afford the necessary information to direct the visitor to the celebrated picturesque spots of this beautiful region; our immediate object is to point out the most important geological phenomena.†

GEOLOGICAL POSITION OF MATLOCK DALE.—That the reader may clearly comprehend the geological character of the romantic district in which he is now situated, we will briefly enumerate the several formations over which we passed, in our rapid transit from London; by the aid of Professor Phillips's geological map, the following description will be easily comprehended.

Our route from the metropolis commenced from the centre of the *Tertiary* strata, upon which London is situated (p. 32. *Wond.* p. 214.), and

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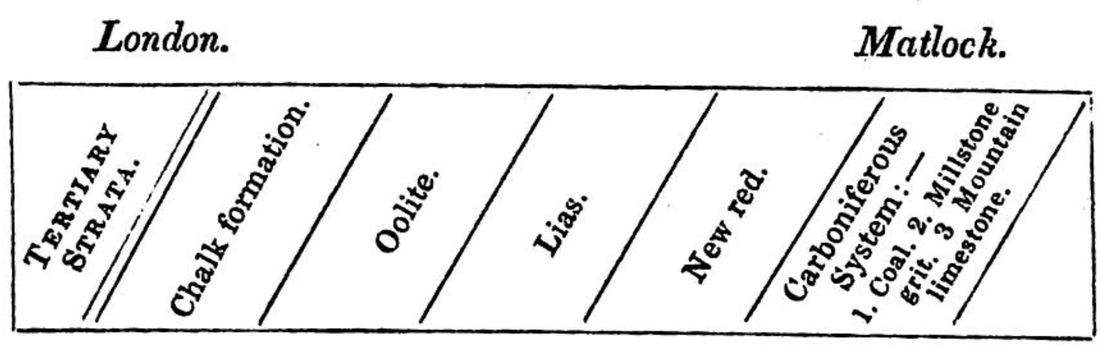
* I may add, as additional recommendations, the excellent accommodation afforded, and the civility and attention of the hostess, Mrs. Evans.

† The book entitled "*The Gem of the Peak,*" by W. Adams, price 1*s.*; and "*Brief Remarks on the Geology and Botany of Derbyshire,*" by the same author, price 1*s.*, will be found to contain much valuable information. The "*Derbyshire Tourist's Guide,*" with plates, 1 vol. 8vo., by E. Rhodes, Esq., price 6*s.*, is a delightful hand-book.

which fills up an extensive depression or basin in the Chalk; we then passed over, or rather (by the tunnel) through the north-west boundary of the *Chalk* basin, and successively came upon the *Portland* stone, and other beds of the *Oolite*, and the *Lias;* the strata of these formations successively rising from beneath each other as we proceeded. In Leicestershire, the beds of the *New Red*, or *Triassic* formation, emerged from under the Lias; and at the Trent Junction, the nature of the deposits was concealed by the alluvial plains of the river. Beyond Derby, we entered upon strata of the *Carboniferous* system, the *millstone grits*, and *sandstones*, and finally reached the *Mountain limestone*, and its associated *Magnesian limestones*, which compose the mountainous district of Derbyshire. The following diagram will serve to illustrate this description.




The immediate vicinity of Matlock is, therefore, a region of Carboniferous limestone, and millstone strata, which, as we have previously explained (see p. 42.), are of marine origin; and those beds that contain organic remains, abound in extinct species of shells, and crinoidea (see p. 317 and 439.). These rocks are also the grand depository of the ores of lead (see *Wond.* p. 609.), calamine, &c., and contain a variety of minerals of great beauty and interest. This district has also been the theatre, in very remote periods, of great physical changes, and the strata have been upheaved and displaced by volcanic action, the solid rocks rent asunder, and beds of mineral substances, rendered fluid by intense heat, have been injected between the layers, and into the fissures of the sedimentary strata; to these revolutions, the present bold and picturesque features of the country are attributable. Here then are phenomena replete with the highest interest; the very beds of molten lava may still be seen—the rents and fissures caused by their explosive action, and now lined with rich metallic ores and spars, may be examined—and the thermal waters, rising in perpetual fountains from an incalculable depth, testify that the internal fires, the sources of these catastrophes, though latent, are not extinguished.

A WALK TO THE INCRUSTING SPRINGS.—The so-called "petrifying springs and wells" of Derbyshire, are celebrated throughout England, for the incrusted birds' nests, baskets, &c. which are very generally purchased by visitors, as mementos of a trip into this county. The nature of this deposition of calcareous matter has already been explained (see p. 52; and *Wond.* p. 58.); and although the objects above mentioned are scarcely worthy of notice, the natural operations by which the tufa and travertine are produced, are extremely interesting.*

Our first stroll shall therefore be to the beds of tufa which have been formed in remote ages by this operation, and now constitute the terrace on which the Old Bath, and two other hotels, and the elegant modern Church, are situated. Proceeding from our Inn, the tufaceous rock may be seen protruding in masses on the right hand, in front of the beautiful parterres of the hotels; and upon crossing the road, where a narrow path leads down to the bed of the river, and nearly opposite to the new church, the lower beds of tufa are exposed in a quarry, from which large blocks of the coarse, porous stone, are extracted for grotto and rock-work. From this spot I collected very fine impressions of the foliage of the oak, elm, and hazel, leaves of adder's tongue (*scolopendrium*), &c. and large portions of moss, beautifully incrusted.†

The origin of this deposit of tufa, which covers

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* If the proprietors of these springs could be induced to follow the example of the Italians at San Filippo (see *Wond.* p. 58.), or of the French, in Auvergne, elegant bas-reliefs, and other beautiful objects, might be obtained, for the incrusting power of the Matlock waters is very considerable.

† I could not obtain any specimens of this kind from the quarrymen, nor from the shops or museums, as they are termed; such objects not being deemed "curiosities" by the good folks of Matlock; and the workmen forbade me to search for more in the quarry!

so large an area along the western flank of the mountain range of Masson Hill, is attributable to the thermal springs having, at some very remote period, issued from a much higher source than at present, and flowing down the side of the hill, into the river at its foot, the water, as it cooled, deposited the lime with which it was charged, on the stems, branches, leaves, and other extraneous bodies. At this time the springs escape from crevices in the rocks, at an elevation of about one hundred feet above the bed of the river; the waters, at their source, have a temperature of from 66° to 68°, and contain free carbonic acid, and minute quantities of muriates and sulphates of magnesia, lime, and soda. Their origin is now concealed, and the water conducted by pipes to the various baths and fountains; but wherever a rill escapes, and flows down the hill, the moss, &c. is quickly incrusted. I was informed, that in about eight months, a basket of eggs would be entirely enveloped in a thick mass of tufa. The uniform high temperature of these waters, shows that they emanate from a very deep source; and it is probable that they originate from steam, which is cooled and condensed as it approaches the surface of the earth. The miners assured me, that the springs burst out from beneath the volcanic rock, here termed *toad-stone*, and that the water, when it first issues, is of a higher temperature than the Matlock Bath water; but its heat is reduced by the cool land springs with which it becomes intermingled.

Most waters that flow through limestone districts deposit travertine more or less abundantly; and I observed several streams in my rambles in the neighbourhood of Matlock, which appeared to possess this property in as great a degree as the thermal springs. There is a lovely waterfall, which issues from the side of a mountain that flanks the road leading by Via Gellia to Middleton Moor, at an elevation of two hundred feet, and flows into the adjacent valley, bounding and dancing from one mossy knoll to another, and appearing, from the opposite hill, like a stream of molten silver, undulating through a carpet of emerald green. The waters of this cascade have formed a thick bed of travertine along the side of the hill; and the stone is of so firm a texture, that the walls of a cottage hard by are constructed of it. I gathered from the banks of this waterfall, bundles of moss and groups of small shells, incrusted with a beautiful white tufa; and impressions of leaves, twigs, &c. were observable in the blocks of travertine recently quarried.*

In contemplating the effects produced by these crystal streams, by which perishable leaves and fragile shells are preserved for ages in solid masses of rock, we are reminded of the forcible and eloquent remarks of Sir Humphrey Davy, when observing

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* Incrustations of moss and wood may easily be obtained from the blocks of travertine at Matlock; but good impressions of foliage are rare.

similar phenomena in the volcanic regions of Italy. "How marvellous are those laws, by which even the humblest types of organic existence are preserved, though born amidst the sources of their destruction; and by which a species of immortality is given to generations, floating, as it were, like evanescent bubbles on a stream raised from the deepest caverns of the earth, and instantly losing what may be called its spirit in the atmosphere!"*

VISIT TO THE CAVERN OF THE HIGH TOR.—After the visitor has taken a general view of the romantic scenery around him, a visit to the cavern at the foot of the High Tor will enable him to comprehend the nature of those physical changes which have imparted to this district its picturesque character. Descending into the valley, and passing northwards, through the only street in Matlock Bath, along the banks of the Derwent, which are beautifully overshadowed by copses and forest trees, the bold cliff of mountain limestone, called the High Tor, the most imposing feature in the dale, suddenly appears on the right bank of the river. This rock rises to the height of four hundred feet; the upper half forming a bare and nearly perpendicular wall of limestone; the lower portion being concealed by brushwood and luxuriant foliage to the river's edge. At this spot, a rude wooden

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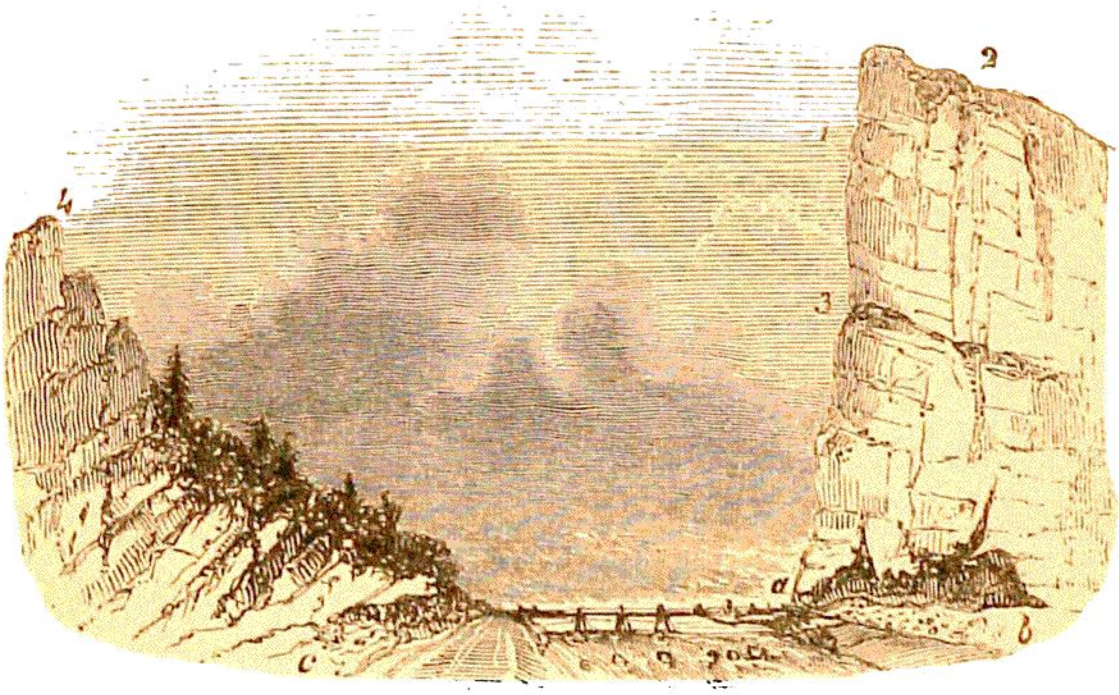
* "Consolations in Travel; or, the Last Days of a Philosopher;" by Sir Humphrey Davy. See also *Wond.* p. 416.

hand-rail is stretched across the Derwent, which is here of considerable breadth, and dashes along over fallen masses of rock in its course towards the south. The High Tor (*Lign.* 162.) consists of a




*G. A. M. del*[t].   *J. Whimper, lign*[t].

LIGN. 162. SECTION ACROSS THE VALLEY OF THE DERWENT, AT THE HIGH TOR, MATLOCK.

1.—The HIGH TOR, composed of strata of MOUNTAIN LIMESTONE.

2.—Capping of MILLSTONE GRIT and DRIFT.

3.—Supposed position of an intrusion of TRAP.

4.—Cliff of limestone on the opposite side of the valley.

*a.*—Entrance to the *High Tor* Cavern.

*b.*—*Trap* seen at the bottom of the Cave.

*c.*—*Trap* beneath the limestone on the opposite bank of the Derwent.

capping of Drift, and of millstone grit (2.); of a series of beds of limestone with encrinites and shells, slightly inclined southward (1.); of a layer of volcanic matter, termed in Derbyshire, *toadstone*, from its mottled yellow and greenish appearance (3.); of the fissure or excavation in the limestone forming the cavern (*a.*); and of a bed of *Trap*, or *toadstone* (*b.*) near the floor at the entrance; and which also appears on the opposite bank of the river (*c.*), beneath the highly inclined and dislocated masses of rock, forming part of the base of Masson Hill. The upper bed of *toadstone* (3.), cannot be seen, for the face of the cliff (although represented bare for the sake of perspicuity in the plan, *Lign.* 162.) is entirely concealed, half-way up, by dense foliage; but an intelligent miner assured me that such was the fact, and that, in sinking a shaft in the opposite hill, *toadstone* was found in a corresponding situation. Upon entering the cavern, which is not of considerable extent, the first phenomenon to be observed is the bed of *toadstone*, which protrudes near the floor, beneath a stratum of limestone. The limestone in contact with the trap is in some places changed to a light green colour, and has a slaty texture, from the effects of intense heat under great pressure (see *Wond.* p. 750.); it is often permeated with veins of pyrites, and white calcareous spar. The inner recesses of the cavern are literally overed, both on the floor and sides, with very large rhomboidal crystals of carbonate of lime, of the form commonly called *dog-tooth spar;* the cave surpasses, in this respect, every other in Derbyshire.

Within a few hundred yards of the cavern, a gallery has been driven into the cliff, and a vein of lead (*galena*) discovered, and worked with some success. Fine masses of blue fluor (provincially termed *blue John*), and double refracting calcareous spar, were also obtained. On the opposite bank of the Derwent, beneath the limestone, and extending along the road-side for two or three hundred yards, a bed of *toadstone*, evidently the continuation of that at the base of the High Tor, is distinctly exposed.

Proceeding northwards, the line of mural precipices, of which the High Tor is the most elevated point, gradually descends; but there is a bold and bare rock, called the Church Tor, from the church of the village of Matlock being situated near its summit, that requires particular remark; for on the face of this cliff the strata present a series of curves, or rather arches, nowhere broken, but having such an appearance as would result from an expansive force from beneath, uplifting a group of horizontal strata, while yet in a soft or plastic state. The upper beds of limestone at the Church Tor abound in marine shells (*Spirifera*, see p. 380, particularly the large species, *S. giganteus*). Such are the appearances presented by the strata in this locality, on the right bank of the Derwent. On the opposite side of the valley, are beds of limestone, many of them varying in mineral constitution from those we have examined, being of a light yellowish dun, or cream colour (hence called *Dun-stone*), and containing magnesia; in these strata, traces of fossil plants are occasionally found. These magnesian limestones are of a granular texture, and extremely hard; they are said to be very rich in lead and calamine, and have been extensively worked. The prevailing rocks on this (the western) side of the valley belong to this group.

GEOLOGICAL FORMATIONS OF DERBYSHIRE.—Before we proceed on our walk, let us sit down awhile on this mossy bank, beneath the magnificent knoll of trees that here overshadows the river, and by a reference to the geological table (p. 41.), and Professor Phillips's map, obtain a clear idea of the nature and succession of the strata around us; in other words, the order of superposition of the deposits of Derbyshire.

1. *Lowermost.* A bed of compact BASALT, or TRAP, (in Derbyshire called *Toadstone,*) of uncertain thickness and extent. This rock consists of mineral matter that has undergone complete fusion, and been erupted from the profound depths of some internal source of intense heat (see *Wond.* p. 742.). The upheaving force thus put in action, having been unequally exerted in different places, the superincumbent beds of limestone have been protruded in dome-shaped masses through the upper strata; and are now seen bent and curved, forming what is termed arched stratification.*

*Vesicular*, or *amygdaloidal* Toadstone; this partakes more

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* My excellent friend, the late Robert Bakewell, Esq., was the first geologist who correctly explained the phenomena here described. See his Introduction to Geology, 5th edit. p. 147.

of the character of *scoriæ*, being full of little cells, or cavities formed by air bubbles; when these cavities are filled with other mineral matter, as is often the case, the rock is termed amygdaloidal. This bed of Trap was formerly considered to be distinct from the lowermost; but it is now supposed, and with much probability, that all the masses of igneous rock that pierce, or are intercalated with, the sedimentary strata, have sprung from one common source, and are but lateral protrusions from some grand mass of erupted materials.*

2. LIMESTONES with intervening layers of clay, and Magnesian limestones, or Dunstones.

3. Alternation of LIMESTONE and SHALE. Many of these limestones abound in organic remains; and it is in this group that the ornamental marbles of Derbyshire are comprised. The upper beds are generally of a slaty texture, and contain layers and nodules of chert, which often afford exquisite siliceous casts of the stems of *Crinoidea* (pulley-stones, see p. 317; and *Wond.* p. 589.), and shells; white chert, or porcelain-stone, and black jasper, or flinty slate, also occur in these beds.

4. MILLSTONE GRIT and SHALE, and coarse sandstones; these form the subsoil of the principal heights of the mountain ranges, their sterile soil supporting only a covering of ling and heath.

5. COAL MEASURES; consisting of beds of Coal, with intervening layers of shale, clay, and ironstone (see p. 96.).

6. NEW RED, or Triassic strata (see p. 39.).

The mineral substances found in the above strata in Derbyshire are very numerous, and the organic remains equally so, and of a highly interesting character.†

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* See an analogous example, *Wond.* p. 752.

† A good catalogue of the principal varieties, will be found

This enumeration of the geological formations of which the country around Matlock is composed, will enable us to proceed on our rambles without further digression; and should the reader be at a loss to comprehend the nature of any of the rocks or strata we may meet with on our way, he can refer to the above description.

Mr. Bakewell, with his wonted penetration, first detected the true character of the stratification of the High Tor, previous writers having described this cliff as being composed of nearly horizontal layers. But this is a deceptive appearance; for although, when viewed in front, or in the direction of their planes, the strata appear to be horizontal, yet they are in reality highly inclined, as may be seen in the line of dip, and enfold or envelope the back of the cliff; and they are continued into the hill (Masson) on the opposite side of the valley, where they present a similar arrangement. The continuity of the strata is broken by the vale of the Derwent, which has evidently originated in a fissure extending along the axis of elevation, in a direction from north to south; and thus formed the water channel for the drainage of the country on the north, and which is now the bed of the river.

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in Mr. Adams's pamphlet previously recommended; and specimens may be obtained at his museum in Matlock; and from Mr. Tennant (Professor of Mineralogy to King's College), 149, Strand, London.

We have already pointed out the curved position of the strata on the face of the *Church Tor*.

EXCURSION TO CRICH HILL.—The appearances observable at the High Tor, are of so striking a character, and involve the consideration of so many interesting phenomena relating to the physical mutations which this district has undergone, that it is desirable, while they are strongly impressed upon the mind, to take an excursion to CRICH, a few miles to the south-east of Matlock. Here there is an entire mountain of limestone, formed by a protrusion of numerous strata many hundred feet in thickness, through the once superincumbent beds of millstone grit and sandstone, into a dome-shaped mass, upwards of 800 feet high. And there it stands, a stupendous monument of one of the past revolutions of the globe, with its arches of rifted rock, supported by a central mound of erupted mineral matter, now cooled down into an amorphous mass of compact basalt! Were there no other object of interest near Matlock, Crich Hill would alone render it worthy of resort.

From the heights above our hotel, looking towards the south-east, a mountain remarkable for its elevation, and obtusely conical configuration, and distinguished by a tower on the summit, forms a striking object on the horizon, at an apparent distance of three or four miles—this is CRICH HILL; and on the same range, to the right, is seen the church-spire of Crich village (see *Lign.* 164.).

A long summer's day is not too long to visit this mountain, and examine all its interesting details. A good pedestrian should proceed with his hammer, and haversack, for every step of the road is replete with interest; and as numerous specimens will be obtained, bags, paper, and boxes should be taken. If an invalid or ladies be of the party, it will be desirable to have a carriage for the day, and dine at the little village of Crich;* and if time permit, the interesting ruins of South Wingfield Manor-House, (once the prison of Mary of Scotland,) about two miles from Crich, may also be visited.

The shortest drive from Matlock to Crich Hill is over Cromford-bridge; but a far more picturesque route, is by the Derby-road to Whatstandwell-bridge (see *Lign.* 165.), and from thence to ascend the hill to Critch, and return home by Holloway; making the entire distance about twelve miles. As our immediate object is to examine the geological features of the mountain, we shall proceed by the nearest road; and upon reaching Scarthing Rock, turn to the left, by Wellersley Castle grounds, having on the right a bold escarpment of mountain

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* A good guide will be a great acquisition, and save much time and trouble; and BENJAMIN FROGGATT, who has conducted Dr. Buckland and other geologists to the principal localities in the neighbourhood, will be found an obliging and intelligent attendant, perfectly conversant with the richest geological and botanical sites around Matlock.

limestone, with layers of chert in nodules, and amorphous masses. At Cromford Canal, the limestone suddenly terminates, and sinks beneath the surrounding alluvial silt of the river valley, and the millstone grit. We will chip off a few specimens of the chert, to examine at leisure. Crossing the bridge, the road winds round the foot of the hills of sandstone, which lie on our left, while on the right is the valley of the Derwent, and the river is seen here and there through openings in the copses and hedge-rows, meandering through the rich meadow-lands of the valley, which are flanked on the west by a magnificent range of lofty hills, clothed with the luxuriant woods of Alderwasley. The character of the scenery from this point of the road, till we ascend the high ground, is faithfully and graphically portrayed by Mr. Rhodes.*

"The road lies through a beautiful valley by the side of the Derwent; sloping meadows, crowned high above with a long range of magnificent woods, skirt the road-side on the left; on the right the river, pursuing its winding way beneath the umbrageous branches of oak, ash, alder, hazel, and sycamore, and bubbling as it passes along, is a beautiful object. About two miles below Cromford-bridge, the road leaves the more open part of the valley, and plunges into the thick woods that environ the little hamlet of Lea; a lovely spot, romantically situated by the side of a sparkling stream, in a deep hollow, amongst steep hills covered with foliage, and fields of the freshest verdure. The houses of this secluded

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* Derbyshire Tourist's Guide, p. 48.

village, with the exception of here and there a comfortable cottage, are handsome residences, nestling among orchards and parterres of flowers. Everything was flourishing most luxuriantly; and when we passed through the place, the hollyhocks, dahlias, and roses, were in full blossom, and gave an extremely bright and cheerful aspect to the scene. The road continues through *Lea Wood* to *Holloway* by a very steep ascent, and from the toll-gate at the top of the hill it traverses the side of a mountainous ridge, covered with wood and intervening rock. The prospect is now magnificent: on the right, a scene of great extent opens to the view, rich in all that constitutes the highest beauty in landscape. The summits of the two ranges of hills that form the eastern and western boundaries of the fertile valley at our feet, are here from three to four miles apart; and the extent from north to south is from ten to twelve. Many minor eminences, rich with wood and intervening verdure, adorn this enchanting scene, through which the Derwent, sometimes hidden by overhanging trees, and sometimes sparkling with light, flows with busy speed and uninterrupted current by Belper, Milford, and Duffield, to Derby; the whole presenting an assemblage of splendid scenery finely diversified, and rich in picturesque beauty. The woods of Alderwasley, that cover the hills from below Whatstandwell-bridge, to the dark pine-crowned eminence of STONNIS, are peculiarly imposing and magnificent."

Near the village of Holloway there are several quarries opened on the side of the hill, which enable us to ascertain that this range is composed of strata of millstone grit and sandstone, highly inclined, and dipping from the hill. The beds are so split and shattered in every direction, that no large blocks can be procured, and the stone, although a good building material, is therefore only employed in the construction of the cottages and houses in the immediate vicinity. The *vignette* of *this volume* represents a mass of the inclined sandstone strata near this place. The reader will recollect that the hills on the opposite side of the valley, on our right, are also composed of similar strata; and that the ridge, covered with fir-trees, marks the bold escarpment of the millstone grit at STONNIS, over Cromford; so that the geological horizon of the valley, as seen from this spot, is wholly formed by the millstone grits and sandstones. A mile beyond Holloway toll-gate, the road turns to the left, and the bare dome of mountain limestone of CRICH HILL is before us. We soon arrive at a limestone quarry, in which the strata are seen to be distinctly arched (see *Lign.* 163, p. 959.), as in the cliff at Matlock *Church-Tor*.

We will alight here to examine the rock more closely, and obtain specimens. Here we see that the strata are inclined both to the right and to the left, and also lean towards the central axis of the hill in front of us; presenting such an appearance as would be afforded by an excavation made in an onion, or other spheroidal body, formed of a series of concentric layers. The limestone in this quarry is of the usual subcrystalline character, abounding in shells, principally spirifera (p. 381.). There are numerous vertical and oblique fissures in the rock, and these are more or less incrusted with minerals and spars, which have evidently been deposited by electro-chemical action, and admirably exemplify the manner in which the rich metallic veins of lead, &c. are distributed in the strata of the interior of the mountain. In a crevice of the rock, in which the mineral contents were undisturbed, the arrangement of the prevailing minerals of this part of Derbyshire, namely, galena *(sulphuret of lead)*, sulphate of barytes (here termed *cawk*), and fluor spar, was beautifully displayed. A layer of the blue sulphuret of lead, or galena, was spread over the surface of limestone forming the walls of the fissure; upon this was a thick stratum of white sulphate of barytes; and on the latter, fluor spar, of a light blue colour, forming cubic crystals on the surface nearest the cavity of the fissure, which therefore appeared to be lined with crystals of fluor.*

About half a mile beyond, we arrive at Wakebridge, near which there are several very productive lead mines. The "*Glory-mine*," one of the richest in Derbyshire, is said, some ten years since, to have been worth from thirty to forty thousand pounds a-year.† A mining establishment, on the left hand, where a powerful steam-engine is constantly at work, affords numerous specimens of the usual Derbyshire spars and minerals; and from

* The workmen at this, and the other quarries, generally have specimens of the fossils and minerals for sale, at moderate prices.

† Derbyshire Tourist, p. 50.

among the heaps of refuse thrown by, the visitor may make an interesting collection. Near this spot, a vertical shaft was sunk in the side of the hill, in search for lead ore, and at the depth of twenty fathoms, a rock of *compact Trap* was reached; the work was continued for a few yards deeper, but ultimately abandoned as fruitless. A gallery was subsequently driven into the side of the hill, lower down, and here, too, the trap was found; thus proving the existence of a central protrusion of igneous rock, over which the bent strata of mountain limestone are now disposed in consecutive layers. Numerous blocks of this compact trap or basalt, some of which are veined with red jasper, lie scattered about the site of the old shaft, and an interesting suite of specimens may be collected. Pursuing our way, the limestone strata are seen in openings on the hill-side, having the same remarkable arrangement as those before described.

Upon arriving where the road divides,* we must proceed on foot and visit the quarries, and examine the exposed masses of rock, that we may clearly comprehend the structure of the mountain. We will now ascend by the pathway that leads to the summit, and on the left, several good sections of the strata are displayed. On reaching the tower on the crest of the mountain (*Lign.* 164, p. 961.), a mag-

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* The carriage should here be sent on to the village, and orders given for refreshments.

nificent panorama bursts upon our sight; but which no language can adequately describe. Here and there bare pinnacles of rifted rock protrude through the green sward; and masses of white, yellowish, and pink sulphate of barytes, pyrites, fluor, and other minerals, lie strewn upon the surface.*

Having reposed for some time at the foot of the tower to enjoy the glorious prospect spread around us, correct our notes, look over, trim, and wrap up our specimens, we will now descend to the north-eastern side of the hill, that the appearance of the strata on that aspect may also be examined. But ere we leave the summit, again let me call your attention to its external configuration. Were it not on too extended a scale, we might suppose that we were standing on an ancient earth-work, or encampment, formed of limestone, surrounded by a deep fosse, or ditch, and flanked by precipitous embankments of millstone grit and sandstone, so strongly defined are the physical features of this remarkable mountain.

We will now visit a large quarry on the eastern side, which presents a fine section of the limestone strata, above 100 feet thick (see *Lign.* 163.), and which, like those we have previously observed, are disposed in curves, and enfold, as it were, the central

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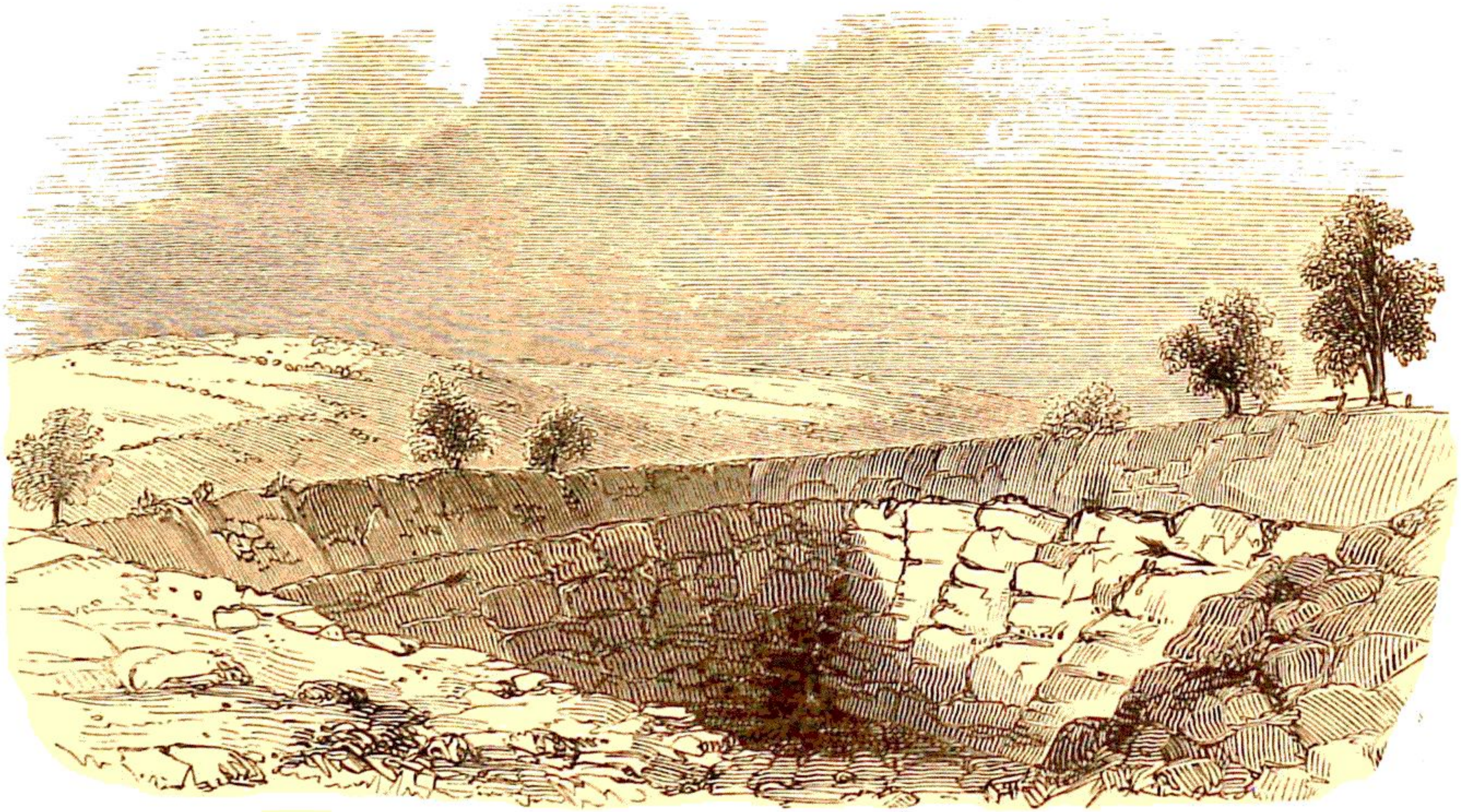
* Good specimens may often be obtained from the piles of stones, and from the walls on the side of the hill.



*Henry Carr, Esq. C. E. del[t].* *J. Whimper, lign[t].*

LIGN. 163. QUARRY OF MOUNTAIN LIMESTONE, CRICH HILL.

axis of the hill; and the rock is shivered and fissured in every direction. A thick bed of drift, or alluvial debris, covers the limestone strata, as shown in *Lign.* 163; and in it, partially rolled blocks of sandstone, some of them of great size, are imbedded. The direction of the dip of the strata in this quarry is indicated by the arrows.

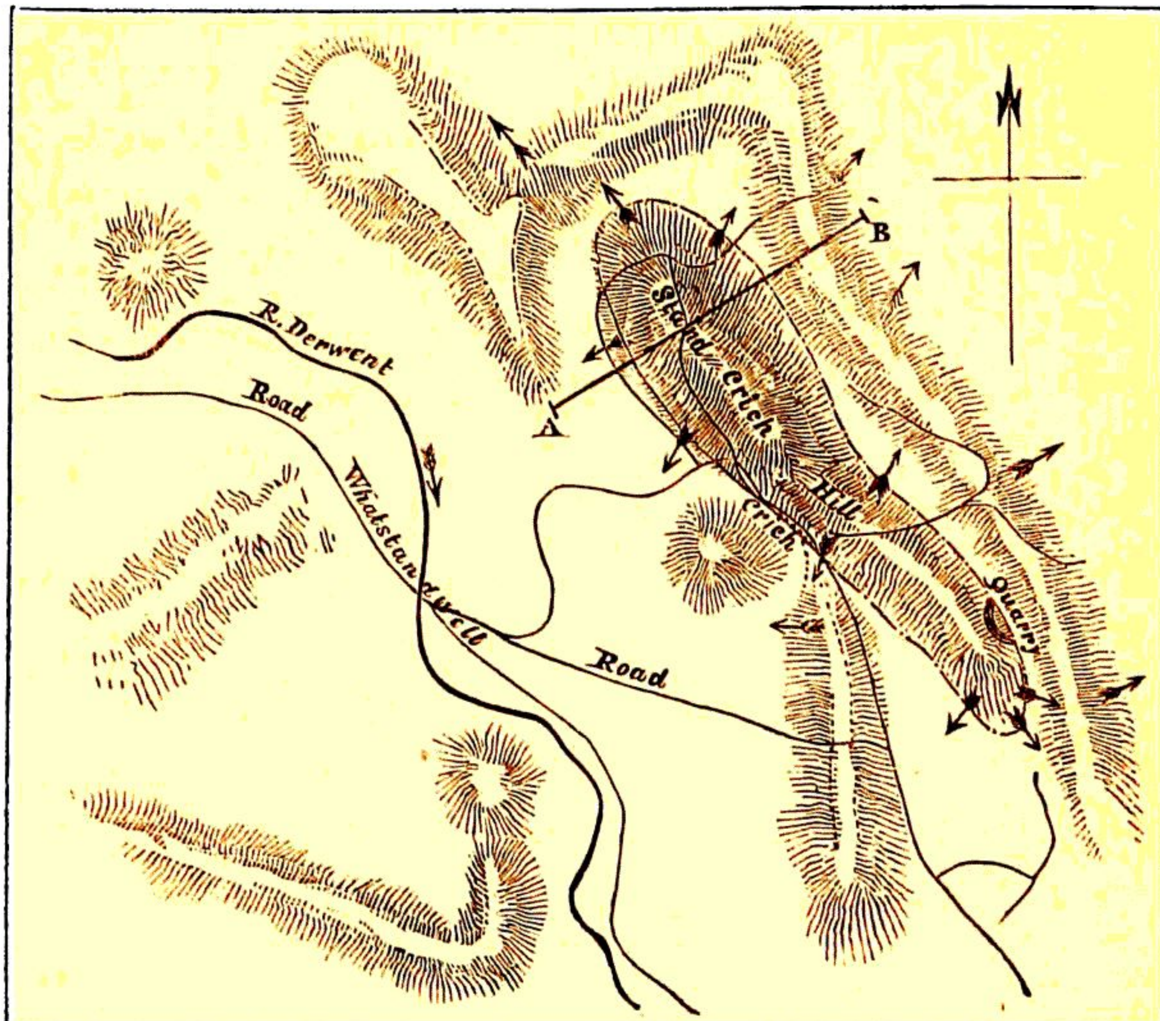
Let us now take a retrospect of the facts investigated during this morning's ramble, and consider how far Mr. Bakewell's interpretation of these phenomena (see p. 950.) is in accordance with the data we have obtained. The outline of Crich Hill, as seen from a moderate distance, is that of an insulated oblong dome, encircled by precipitous escarpments, or angular eminences of less elevation. The annexed sketch (*Lign.* 164.), by my friend, Henry Carr, Esq. C.E., of Duffield, to whom I am also indebted for a survey of Crich Hill, and admeasurements of the dip of the strata, will render this feature in the physical geography of the country more apparent.

In *Lign.* 164, the protruded elongated cone of mountain limestone, is denoted by the tower, or *Stand*, on the summit; and the other heights, and the foreground, are composed of millstone grit and sandstone. The highest point of limestone is 716 feet above the level of the Derwent, in the adjacent valley; and was estimated by Mr. Bakewell at about 900 feet above the level of the sea. The hill of sandstone on the right, on which the mill stands, is 462 feet high, and conceals Crich village in this view; that in the middle distance, on the left, marked *a*, is 400 feet high.

This disposition of the millstone escarpments around the central cone of elevated limestone, is

Drawn by Henry Carr, Esq. C. E. — J. Whimper, lign^t.

LIGN. 164. VIEW OF CRICH HILL, DERBYSHIRE, from the West.




LIGN. 165. GROUND PLAN OF CRICH HILL, Derbyshire.
(*Scale, one inch to a mile.*)
By HENRY CARR, Esq. C. E., from actual Survey.

The area, enclosed within a line, and marked *Stand, Crich Hill*, is the elevated oblong dome of *limestone*. All the surrounding country is composed of *millstone grit* and *sandstone*.

The arrows on the boundary line of Crich Hill, denote the direction of the dip of the limestone strata, in nine positions, measured and determined by Mr. Carr. The dip varies from 20° to 50°; the greatest inclination is on the south-east of the tower.

The arrows on the surrounding millstone escarpments, mark the dip of those strata in a sufficient number of stations, to convey a general idea of the position of the mountain masses environing Crich Hill.*

* At Whatstandwell, a bridge crosses the Derwent; and close by, there is the BULL Inn, where good accommodation and sleeping apartments may be obtained.

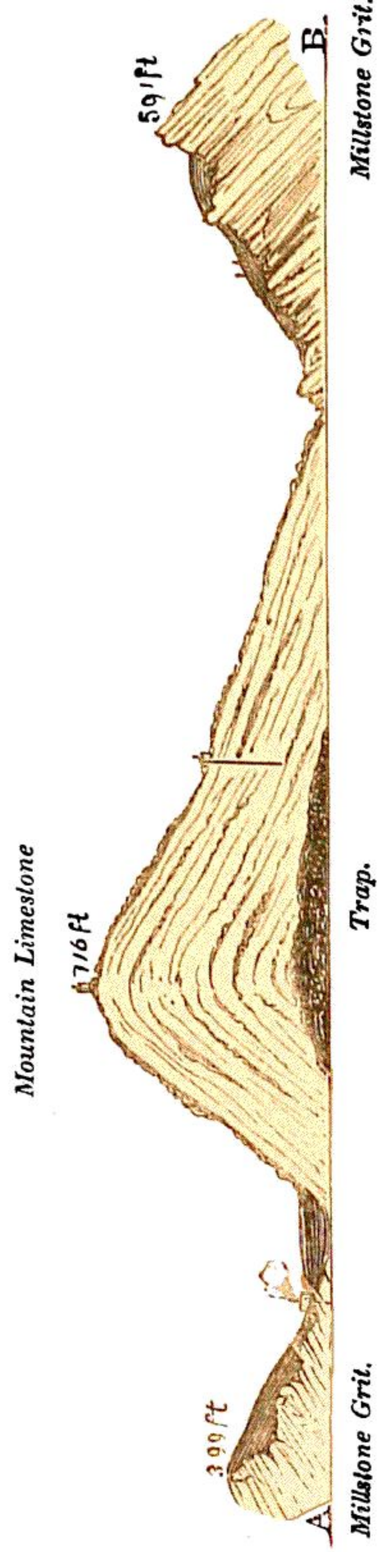
shown in more detail in the ground-plan, *Lign.* 165.

Thus we perceive that the strata of mountain-limestone, dip from the centre of the hill in every direction, as indicated by the arrows, at various angles, from 20° to 50°: and those of the sandstone hills, which form an irregular zone around Crich, are also highly inclined, and in like manner dip from the central axis, as is shown by the direction of the arrows. Now we know, by observations made in places where the relative position of the Millstone and Limestone has suffered no disturbance, that these two series of strata are disposed horizontally and conformably upon each other, thus—

1. *Uppermost.*—MILLSTONE GRIT AND SANDSTONE.

2. *Lowermost.*—MOUNTAIN LIMESTONE.

It is therefore evident, that at Crich the strata No. 2 must have been forced up, and protruded through the strata No. 1, or they could not occupy their present position. We remarked, on ascending Holloway Hill, the great disturbance which the Millstone beds had sustained (see the vignette of this volume); and the shaft and gallery near Wakebridge (p. 957.), disclosed the existence of a mass of basalt, or *trap*, of unknown extent, beneath the limestone, in the centre of the mountain; while the fissures and crevices, filled with metallic ores and spars, attest the action of intense heat, under great pressure. According to a survey made by my son, a section in the line marked A—B, on the plan, *Lign.* 165, presents the following arrangement of the strata:



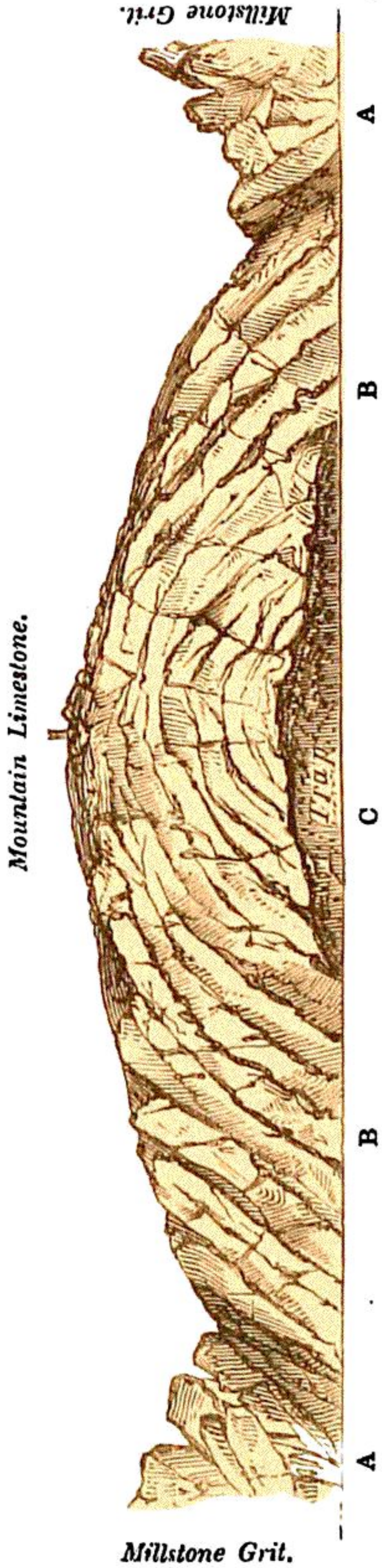

LIGN. 166. SECTION OF CRICH HILL; from A to B on the plan, *Lign.* 165.
(*Natural scale*).

By REGINALD NEVILLE MANTELL.

A, B.—Strata of *Millstone Grit*, highly inclined, and dipping from the central axis.
Protrusion of Mountain Limestone, on the summit of which is Crich Tower, 716 feet above the level of the river Derwent.
Central mass of TRAP, reached by a vertical shaft from above, and by a gallery on the side of the hill.

the heights are from actual admeasurements (*Lign.* 166.).

From the data thus obtained, we may construct an ideal section in illustration of these phenomena, as in the following diagram (*Lign.* 167.).




Lign. 167. Ideal transverse Section of Crich Hill.

A, A.—Highly inclined strata of *Millstone Grit.*
B, B.—Arched strata of *Mountain Limestone.*
C.—A central nucleus of *Trap*, or *Toadstone.*

Here then, as Mr. Bakewell forcibly observed, "we have cause and effect in conjunction." Here is the cooled and consolidated molten rock, whose expansive force elevated the horizontal strata of limestone, and forced them through the superincumbent beds of grit and sandstone. But this eruption must have taken place under great pressure, and at the bottom of the sea; for had the phenomena been sub-aerial, the result would have been altogether of a different nature; and we should have had cooled lava streams, and not masses of basalt.

We have seen that the strata rise round and enfold this central nucleus of volcanic rock, displaying nearly hemispherical segments and curves. Now if we suppose a vertical transverse fissure across such a hill as that represented in the diagram (*Lign.* 167.), the face of the remaining strata would be in every respect similar to that of the HIGH TOR (see *Lign.* 162, p. 945.); namely, a mass of *Trap*, or *toadstone*, at the base, and a series of arched strata of limestone above; with fissures containing ores of lead, zinc, barytes, &c. and various kinds of spar.

To a mind accustomed to investigations of this nature, a slight examination of the phenomena under review, will, I apprehend, suffice to demonstrate the correctness of these deductions; but I may have failed to place the subject before the general reader in an intelligible and lucid point of view; should this be the case, still, if the attempt to present a familiar exposition of the physical structure of this remarkable district, shall induce him to visit the scenes I have so imperfectly portrayed, and interrogate Nature in a right spirit, the hours we have passed together in our excursion to Crich Hill, will not have been spent in vain; for in the beautiful language of the noble bard;—

> "To sit on rocks, to muse o'er flood and fell,
> To slowly trace the forest's shady scene,
> Where things that own not man's dominion dwell,
> And mortal foot hath ne'er or rarely been:
> To climb the trackless mountain all unseen,
> With the wild flock that never needs a fold;
> Alone o'er steeps and foaming falls to lean;
> This is not solitude; 'tis but to hold
> Converse with Nature's charms, and view her stores
> unroll'd."
>
> CHILDE HAROLD, Canto II. XXV.

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SPECIMENS OF FOSSILS AND MINERALS.—On our return, our first care must be to look over all the specimens we have gathered, arrange them, and select those which are the most illustrative of the phenomena we have examined; and ticket every specimen, as recommended in the Instructions, (p. 891.). The fossils, consisting of several species of *spirifera* (p. 380.), and other brachiopoda, and of portions of encrinital stems (p. 317.), require no particular care. The rocks should comprise specimens of the different varieties of limestone and sandstone; and of the green limestone, altered by contact with the toadstone; and examples of the compact trap, and of the variety veined with red jasper,—of the amygdaloidal toadstone,—and the vesicular, or that in which the air cavities are empty. The minerals should comprise the ores of lead, zinc, barytes, fluor and calcareous spar; of the latter, some good clear pieces should be selected, that will exhibit its double refracting property. Of the common metal, *Pyrites*, a few specimens should be preserved; this mineral, from its splendid yellow appearance, is often mistaken for gold; but a mere blow of the hammer will immediately detect it, for *Pyrites* is brittle, and readily cracks to pieces, while gold, as is well known, is remarkably ductile. If the collector be not satisfied with the fruits of his day's researches, he should look over the catalogue of Mr. Adams, and purchase such specimens as will render his collection sufficiently extensive, to present a full illustration of the geological character of the scenes he has this day visited.

There is a variety of sulphate of barytes from near Youlgreave, exhibited in the shops at Matlock, of which one or two examples should be obtained. The surface of the polished specimens much resembles the rich variegated appearance of dark tortoise-shell. This mineral has been formed, like the common calcareous stalactite, by infiltration through some porous rock; transverse sections exhibit concentric layers of various shades; while the longitudinal have the varied colours disposed like those in tortoise-shell.

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## NOTES FOR A GEOLOGICAL EXCURSION BY CROMFORD, UP BONSAL VALLEY, BY VIA GELLIA, TO MIDDLETON MOOR; RETURNING BY STONNIS.

This excursion will present many objects of interest, and one day at least should be devoted to the examination of the different localities pointed out in the following notes. *To Cromford, and then

* Benjamin Froggatt should be engaged to conduct the pedestrian; and a carriage party would also do well to place themselves under his guidance.

take the road that leads through BONSAL vale. A fine range of limestone on the right, and a sparkling stream (Bonsal-brook) on the left. On the banks of this brook, there is a manufactory of mineral colours (Pooley's) well worthy a visit. But before we reach this establishment, there is an opening on the hill-side where the strata are exposed, and a bed of Trap is seen beneath the limestone; near this place, specimens of fluor, calc-spar, &c., that have been thrown out in forming the excavation, may be collected. From beneath the trap a warm spring issues and flows into the neighbouring brook. Proceed up the road leading to *Via Gellia*, and through a valley flanked with high ranges of limestone and dun-stone. On the right, is the beautiful cascade previously mentioned, near *Dunsley* (see p. 943.). This valley is a celebrated botanical region, for several species of plants, which are of great rarity, or unknown elsewhere, are here met with. At the direction post, turn to the left up the steep hill that leads to Middleton Moor. On each side numerous fossils of the mountain limestone may be collected from the blocks lying on the flanks of the hill. Views splendid in picturesque scenery, and of a highly interesting geological character, are obtained as we ascend. On the summit of Middleton Moor, which is from 1,300 to 1,400 feet above the level of the sea, a most extensive panoramic view of the surrounding country may be obtained. The geological map will enable the observer to identify the crags of Charnwood Forest, the High Peak, &c. &c. Almost every part of the Moor is studded with the disused shafts of exhausted mines, and which are so carelessly covered over as to be extremely dangerous, and the visitor must bear this caution in mind; for the heaps of stone placed at irregular intervals on the hill, and which tempt the geologist to seek for specimens, are for the most part piled over the openings of deep shafts.*

Pass on by Wirksworth, to the quarries of mountain limestone, where the encrinital marble, so largely employed for side-boards, chimney-pieces, &c., is procured. Near the approach to the entrance of the quarry, an instructive example of curved strata of limestone is seen on the left; and on the right, a fine vertical artificial section. On the weathered surface of the left side of this entrance, and on the face nearest the quarry, good specimens of the stems and ossicula of the usual Derbyshire crinoidea may be extracted (see *Wond.*

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* My son narrowly escaped being drawn in by a heap of stones which gave way under his feet, and suddenly disappeared in the chasm below. In rambles of this kind in a mining country, the young geologist must, therefore, be upon his guard, or he may be engulphed with masses of limestone in some deep chasm, and his bones, incrusted with stalactite, form an ossiferous breccia, that in future ages may perplex some collector of organic remains to determine their relative antiquity!

p. 588.), from the layers of reddish limestone; and good blocks of the marble may be selected. Large *spirifera* can be procured from the limestone in these quarries; the quarrymen often have specimens. On the right hand of the entrance, layers of flinty slate (called partings of *black bind* by the miners) occur between the beds of limestone. In a field near this quarry, on the left of the road leading to Cromford, where some mining operations are going on, blocks of the stone called *chert*, have been thrown up, and often contain beautiful examples of the pulley-stones (*Wond.* p. 588.), or siliceous casts of the stems of the crinoidea. A large collection of fossils may be gathered in the localities above mentioned.

We now drive to the escarpment of millstone grit at STONNIS, called *Black-rock*, whose pine-clad summit forms so conspicuous an object in the view from Crich Hill (see p. 955.); it is about a mile from Cromford, and overlooks Matlock Dale. On the right of the road, the refuse workings of a mine cover the side of the hill; among which some specimens of spars or minerals may perhaps be found.

But the grand attraction of Stonnis, is the view of Matlock Dale and the surrounding mountains, obtained from the verge of the precipitous escarpment of sandstone rocks, under the knoll of pines. It is, indeed, a scene of transcendent beauty and magnificence; and is said, by one who has ascended every mountain top, and traversed every ravine and valley in this district, to be unrivalled.

"In that species of beauty which in landscape scenery approaches to grandeur, it is unequalled in Derbyshire. The parts of which it is composed are of the first order of fine things, and they are combined with a felicity that but rarely occurs in nature. Scarthing-Rock, the woods of Willersley Castle, Matlock High Tor, the hills of Masson, Crich, and Riber, are all noble objects; and the rude masses that constitute the foreground of the picture, are thrown together, and grouped and coloured in a manner strikingly picturesque. I have scaled the highest eminences in the mountainous districts of Derbyshire—seen from their summits the lovely dales that repose in tranquil beauty at their base—marked the multitude of hills included within the wide horizon they command, and my heart has thrilled with emotion at the sight; but not an eminence that I ever before ascended—not a prospect, however rich and varied, which I thence beheld—is at all comparable with the view from Stonnis." *

Every one possessed of taste and feeling, who gazes upon this glorious landscape, will partake, in a greater or lesser degree, of the emotions thus finely expressed by the ardent lover of the sublime and beautiful in nature; but to the natural philosopher, the physical characters of this enchanting region are fraught with a deeper interest, and present subjects for the most profound contemplation. To him the rocks and the mountains are the grand monuments of nature, on which are inscribed the history of the physical revolutions of the globe, which took place in periods incalculably remote, and long antecedent to the creation of the human race. They

* Derbyshire Tourist's Guide, p. 42.

present to his mind a succession of events, each so vast as to be beyond his finite comprehension; ages of tranquillity, with lands and seas teeming with life and happiness, succeeded by periods in which the earthquake and the volcano spread universal ruin and destruction—and they teach him that all these awful changes bear the impress of the ALMIGHTY's hand, and were subservient to the eternal purpose of rendering this planet the fit abode of MAN, during his mortal pilgrimage.

# CHAPTER XXVI.

## NOTES FOR A GEOLOGICAL EXCURSION TO CHARNWOOD FOREST, TO EXAMINE THE CENTRAL GROUP OF PLUTONIC ROCKS OF ENGLAND; AND THE CARBONIFEROUS AND CAMBRIAN STRATA, THROUGH WHICH THEY HAVE BEEN ERUPTED.

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IN the central county of our Island, within a hundred miles of the Tertiary deposits of the South-east of England, a group of plutonic rocks, emerges from beneath the strata of limestone, coal, and red marl, which constitute the principal geological features of the midland provinces, and rises up into the bold and picturesque range of hills of CHARNWOOD FOREST. Almost the entire series of British rocks is now brought by the railroads within a few hours distance of the metropolis; and the geological inquirer may, in the course of a fortnight, examine in their natural situations, the Eocene deposits of the London and Hampshire basins—the Cretaceous and Wealden strata of Sussex, Kent, and Surrey—the Oolitic, Liassic, Triassic, and Carboniferous systems—the Mountain limestone, and its metalliferous treasures—Traps, or ancient lavas, and their effects—strata of the Cambrian, or Slate system—and, lastly, Granite, Sienite, Porphyry, and other modifications of the plutonic or igneous rocks. The present notes refer to two or three days spent in exploring the country around Leicester, and in examining the granite of Mount Sorel*—the slate quarries of Swithland—the sienitic crags of Bardon Hill—the porphyritic masses of Markfield, and Grooby—and the coal-mines of Whitwick. On our previous excursion by railway to Leicester, (see Excursion to Matlock, p. 934.), the order of the succession of the strata from the metropolis to that town was described; on this occasion it will only be requisite to direct the traveller's attention to the abrupt isolated hills, by Hinckley, Grooby, and the craggy peaks of Charnwood Forest, in the distance, on the left of the railroad, before reaching Leicester. If a pedestrian excursion be resolved upon, three or four days at least will be required to follow the route presently pointed out; in a carriage and pair, it may be accomplished in a long summer's day, by starting from Leicester at six, and returning by ten or eleven.†

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* Sorel, a corruption of *Soar Hill*, or hill on the river Soar.

† It may be well to remind the visitor that at Leicester, the following objects are worthy of notice:—the Roman Milestone, now placed in the High-street; the remains of the Roman Wall; and the Blue Boar Hotel, where Richard III. slept the night before the battle of Bosworth.

The geological localities to be visited in this excursion are the following:—

I. BARROW-ON-SOAR.* *Lias limestone.*—The quarries at this locality are celebrated for the organic remains that have from time to time been obtained from the limestone (see p. 714). Bones of Ichthyosauri and Plesiosauri; fishes (*Dapedius*, p. 636.), and leaves of cycadeæ, and fossil wood; ammonites, terebratulæ, &c., may generally be obtained.

Although at the very foot of the plutonic rocks, and on the verge of the grand focus of volcanic action, which erupted the sienitic masses of Charnwood Forest, the strata in this spot appear to have suffered but little disturbance. But this phenomenon is in accordance with what occurs in other volcanic districts. For, as M. Constant Prevost remarks, volcanoes may open across all the strata, without occasioning great derangements; thus, at Limagne, Aurillac, and Puy (see *Wond.* p. 264.), the tertiary strata have preserved their horizontality, even around the vents through which issued the volcanic matter, that covered those countries with numerous cones of eruption.

II. MOUNT SOREL. *Granite and Sienite.*—The

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* There is a station at Barrow, and the pedestrian may be put down within a short distance, by the railway.

road from Leicester ascends a ridge of Triassic, or new red strata, called Birstal Hill, from whence there is a fine view of the town. In the meadows on the left, some ruined walls, covered with ivy, mark the site, and are the only remains of the Abbey, in which Cardinal Wolsey expired. Approaching MOUNT SOREL, an abrupt hill, with a mill on the summit, denotes, from a considerable distance, the geological character of the spot. There is a small Inn in the village, where accommodation may be procured. Visit the quarries, and also the establishment of Mr. Jackson, where the granite is worked into pillars, sideboards, &c.*

The hill is about 120 feet in height, and 1,400 yards long; and is estimated to contain about two hundred millions of cubic feet of workable granite, above the general level of the district.†

III. SWITHLAND. *Cambrian strata, or Slate-rocks.*—From Mount Sorel proceed to Swithland: as we approach the quarries, the employment of slate for every available purpose, in the footpaths, walls of cottages, &c., indicates the abundance of this material in the neighbourhood. At Swithland, the quarries are very extensive, and expose magnificent

* An interesting account of this manufactory will be found in Sir Richard Phillips's "PERSONAL TOUR."

† The granite resembles that of Aberdeen, but contains a larger proportion of felspar.

sections, from 100 to 120 feet thick, of strata of Slate, highly inclined; and forming one side of an anticlinal axis, the summit of which will be passed over in our route by Woodhouse. In one quarry, at the time of my visit, a series of nearly horizontal strata of red marl was exposed, lying unconformably upon the edges of the highly inclined beds of Slate. The Slate-rocks of Charnwood Forest have a single anticlinal axis, which strikes from N.N.W. to SS.E.; and the axis of the adjacent coal-field of Nuneaton has a similar direction.*

IV. WOODHOUSE. *Slate-rocks.*—From Swithland to Woodhouse, is a continuation of the highly inclined Slate strata. The village is romantically situated on the ridge, or crest, of the anticlinal axis of the Cambrian system of Charnwood Forest. On the sides of the road, there are occasional openings where the strata are exposed. There is, in particular, a fine section on the side of the elevated point on which the church and school are built, lying to the left of the road in the approach from Swithland. A day might be well spent in this place, and at Swithland.

V. BARDON HILL. *Sienite.*—We next proceed to Bardon Hill, ascending to the highest ridge of the protruded mass of igneous rock, of which this moun-

* Murch. Sil. Syst. p. 569.

tain-range is composed. The craggy and bare pinnacles which are every where presenting themselves, shooting up, as it were, from the green sward, cannot fail, from their novel and striking character, strongly to impress the mind of the young geologist, who now, for the first time, visits a region of plutonic rocks. The view from the summit of the hill is grand and imposing; it should be studied with a geological map of the country before us, that the position of this central mass of volcanic rocks, and its relation to the surrounding sedimentary strata, may be fully comprehended.

VI. Whitwick and Snibstone. *Coal measures.* —Spread around the foot of the Sienitic mountain we are descending, are the coal-bearing strata of the Carboniferous system; and in the works at *Whitwick* and *Snibstone*, the geological inquirer can examine the nature of these deposits in the coal-mines, which he should descend, and obtain specimens of the strata and fossils from the beds *in situ.**

Among the refuse of the workings thrown up from the various shafts, search should be made for

* Should he be so fortunate as to see the resident engineer of Snibstone Colliery, Mr. George Vaughan, he will be certain of meeting with a courteous reception, and every facility for pursuing his inquiries, descending the shaft, and obtaining fossils. Mountain limestone is brought to this place to be converted into lime; and good specimens of shells, encrinites, &c. may sometimes be extracted from the blocks of stone

stems of *calamites* (p. 110.), *seed-vessels* (p. 153.), *fern-leaves* (p. 81.), &c.

A section from Whitwick, through Charnwood Forest, to Barrow-on-Soar, in the direction of the route we have traversed, would give the following succession of rocks:—1. Whitwick; *Coal-strata*, highly inclined. 2. *Slate-rocks* of Woodhouse, highly inclined. 3. Protrusions of *Sienite*. 4. *Slate-rocks* of Swithland, highly inclined, with unconformable strata of red marl. 5. *Granite* and *Sienite* of Mount Sorel. 6. *Red marl* and *sandstone*, supporting the *Lias*, at Barrow-on-Soar.

The pedestrian should spend one or two days at Snibstone, where there is humble, but comfortable accommodation.

VII. MARKFIELD AND GROOBY. *Sienite and Porphyry*, &c. These places may be visited on our way back to Leicester.

*But,* COURTEOUS READER, *I am compelled suddenly to bid thee farewell, for my publisher warns me that the limits originally assigned to these volumes, are far exceeded, and that more extracts from my note-book cannot be admitted. Here then, we part—proceed on thy excursion, and good fortune attend thee! And if thou hast derived any gratification from our wanderings, and feel disposed to accompany me to "fresh* *fields, and pastures new,"* *we may perhaps meet again, in a little volume, to be entitled* "GEOLOGICAL RAMBLES IN VARIOUS PARTS OF ENGLAND."

"The *Body* may decay, but by the might
Of the Soul's flame, *Mind* shall not lose its right."

SIR E. BRYDGES.

*Farewell!*

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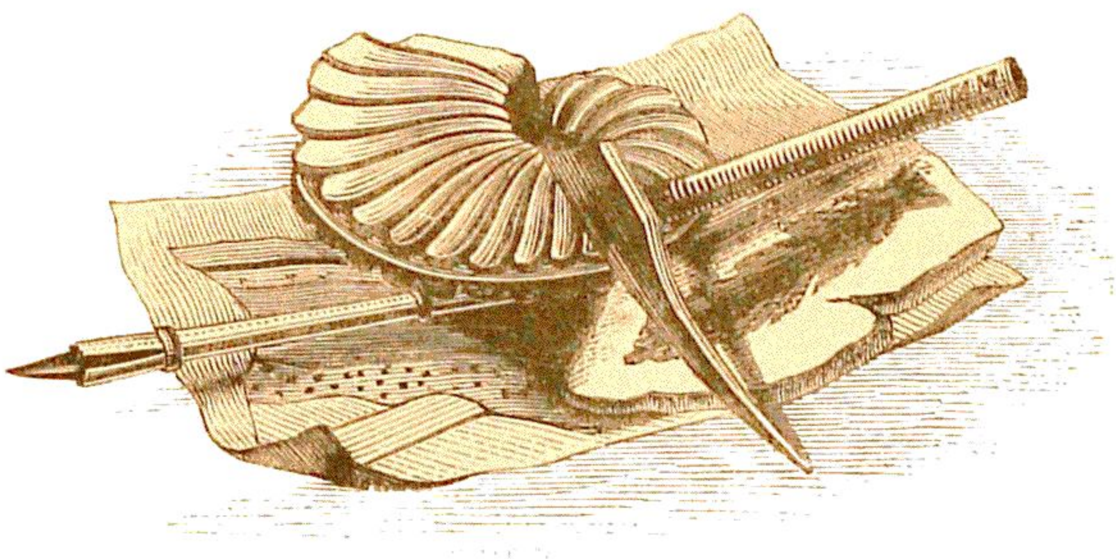

FINIS.

# A GEOLOGICAL EXCURSION TO TILGATE FOREST; A.D. 2000.

By Thomas Hood, Esq.

*(Anticipatory; for the* 100*th edition of the Medals of Creation.)*

"Vincit omnia *amor*." Ovid.
................. *hammer*. Hood.

Time has been called the test of truth, and some old verities have made him testy enough. Scores of ancient authorities has he exploded like Rupert's drops, by a blow upon their tales: but at the same time he has bleached many black-looking stories into white ones, and turned some tremendous bouncers into what the French call *accomplished facts*. Look at the Megatherium or Mastodon, which a century ago even credulity would have scouted, and now we have *Mantell*-pieces of their bones! The headstrong fiction which Mrs. Malaprop treated as a mere allegory on the banks of the Nile, is now the *Iguanodon!* To venture a prophecy, there are more such prodigies to come true.

Suppose it a fine morning, Anno Domini 2000; and the royal geologists, with Von Hammer at their head—pioneers, excavators, borers, trappists, grey-wackers, carbonari, field-sparrers, and what not, are marching to have a grand field-day in TILGATE FOREST. A good cover has been marked out for a find. Well! to work they go; hammer and tongs, mallets and threemen beetles, banging, splitting, digging, shovelling; sighing like paviours, blasting like miners, puffing like a smith's bellows—hot as his forge—dusty as millers—muddy as eels—what with sandstone and gritstone, and pudding-stone, blue clay and brown, marl and bog-earth—now unsextonizing a petrified bachelor's button—now a stone tom-tit—now a marble gooseberry-bush—now a hap'orth of Barcelona nuts geologized into two-pen'orth of marbles—now a couple of Kentish cherries, all stone, turned into Scotch pebbles—and now a fossil red-herring with a hard *row* of flint. But these are geological bagatelles! We want the organic remains of one of Og's bulls, or Gog's hogs—that is, the *Mastodon*—or Magog's pet lizard, that's the *Iguanodon*—or Polyphemus's elephant, that's the *Megatherium*. So in they go again, with a crash like Thor's Scandinavian hammer, and a touch of the earthquake, and lo! another and greater *Bony-part* to exhume! Huzza! shouts Field-sparrer, who will spar with any one and give him a stone. Hold on, cries one—let go, shouts another—here he comes, says a third—no, he don't, says a fourth. Where's his head?—where's his mouth?—where's his caudal?

What fatiguing work it is only to look at him, he's so prodigious! There, there now, easy does it! Just hoist a bit—a little, a little more. Pray, pray, pray take care of his lumbar processes, they're very friable—"Never you fear, zur—if he be FRIABLE, I'll eat un."

Bravo! there's his cranium—Is that brain, I wonder, or mud?—no, 'tis conglomerate. Now for the cervical vertebræ. Stop—somebody hold his jaw. That's your sort! there's his scapula. Now then, dig boys, dig, dig into his ribs. Work away, lads—you shall have oceans of strong beer, and mountains of bread and cheese, when you've got him out. We can't be above a hundred yards from his tail! Huzza! there's his *femur!* I wish I could shout from here to London. There's his *tarsus!* Work away, my good fellows—never give up; we shall all go down to posterity. It's the first—the first—the first nobody knows what—that's been discovered in the world.

Here, lend me a spade, and I'll help. So, I'll tell you what, *we're all Columbuses*, every man Jack of us! but, I can't dig—it breaks my back. Never mind: there he is—and his tail with a broad arrow at the end! It's a *Hylæosaurus!* but no—that scapula's a wing—by Saint George, it's a flying dragon.

Huzza! shouts Boniface, the landlord of the village Inn that has the St. George and the Dragon as his sign.

Huzza! echoes every Knight of the Garter.

Huzza! cries each school-boy who has read the Seven Champions.

Huzza! huzza! roars the illustrator of Schiller's Kampf mit dem Drachen.

Huzza, huzza, huzza! chorus the descendants of Moor of Moor Hall!

The legends *are* all true, then?

Not a bit of it! cries a stony-hearted Professor of fossil osteology—Look at the teeth, they're *all molar;* he's a *Mylodon!* That creature ate neither sheep, nor oxen, nor children, nor tender virgins, nor hoary pilgrims, nor even geese and turkeys—he lived on—

What? what? what? they all exclaim—

Why, on raw potatoes, and undressed salads, to be sure!

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# MISCELLANEOUS.

## *List of Dealers in Fossils, Minerals, &c.*

### LONDON.

CUTTELL, Mr., 52, New Compton-street, Lapidary. Prepares fossil teeth, &c. for the microscope.

DARKER, Mr., Lapidary, 9, Paradise-street, Lambeth. Fossil and recent objects for the microscope. Specimens of the infusorial earths; teeth of fishes and reptiles, marbles, &c.

EDWARDS, 40, High-street, Camden Town. For boards for cabinets, to affix fossils, shells, &c. instead of trays.

McLELLAN, 107, Great Russell-street, Bloomsbury. Manufactures the trays for the British Museum. Wooden trays with black sides, 2 inches by 2, to 6 inches by 2, price 7*s.* per dozen. This price is much too high, except for public collections. Common card or pasteboard trays answer every purpose.

SOWERBY, Mr. G. B. (the eminent naturalist), 50, Great Russell-street, Bloomsbury. All kinds of fossil and recent shells.

STUTCHBURY, Mr., 47, Theobald's-road. Fossils, minerals, and objects of natural history in general, at very moderate prices. Series of specimens of fossils and minerals, illustrative of any particular department of the science, are made up, arranged, and ticketed. Mr. S. also attends and arranges private collections; and gives instruction in mineralogy, geology, conchology, &c.; sciences in which he is eminently skilled.

TENNANT, Mr. J., Professor of Mineralogy to King's College, 149, Strand. This establishment is too well known to require comment. Every purchasable species of fossil, mineral, or shell, may here be obtained; as well as the various microscopic fossils, infusorial earths, slices of teeth, and wood, marble, &c. The collections formed by Mr. Tennant for the student in Geology, Palæontology, and Mineralogy, are admirably calculated to afford that acquaintance with specimens, so indispensable to the acquisition of a knowledge of Geology. A series may be obtained, illustrative of the system of instruction suggested in these volumes, and arranged in a sequence corresponding to the order in which the fossils are described. The price of a mahogany cabinet with five trays, containing 200 specimens, illustrative of the elementary works on Geology, is five guineas: cabinets with fewer and less valuable specimens from two to three guineas. The following is an outline of the contents of the five guinea cabinet—

MINERALS which are either the components of Rocks, or occasionally imbedded in them:—Quartz, Agate, Chalcedony, Jasper, Garnet, Zeolite, Hornblende, Augite, Asbestus, Felspar, Mica, Talc, Tourmaline, Calcareous Spar, Fluor, Selenite, Baryta, Strontia, Salt, Sulphur, Plumbago, Bitumen, &c. &c.

NATIVE METALS, or METALLIFEROUS MINERALS; these are found in masses or beds, in veins, and occasionally in the beds of rivers. Specimens of the following Metallic Ores are put in the Cabinet:—Iron, Manganese, Lead, Tin, Zinc, Copper, Antimony, Silver, Gold, Platina, &c.

ROCKS; Granite, Gneiss, Mica-slate, Clay-slate, Porphyry, Serpentine, Sandstones, Limestones, Basalt, Lavas, &c.

SILURIAN FOSSILS from the Llandeilo, Wenlock, and Ludlow Rocks.

*Secondary Fossils* from the Devonian, Carboniferous, Lias, Oolite, Wealden, and Cretaceous Groups.

*Tertiary Fossils* from the Plastic Clay, London Clay, Crag, &c.

Mr. Tennant has also models of many unique and rare fossils; as for example, of the horn, claw-bones, &c. of the Iguanodon; lily encrinite; small models of the upright coal-trees, near Bolton; Mr. Sopwith's models of stratification, &c.

Topping, Mr., 1, York-place, Pentonville-hill; supplies boards and cases, and every kind of fossil infusoria, &c.; polished slices of fossil wood and teeth; and all kinds of microscopical objects, admirably prepared, and at moderate prices.

Microscopes.—A microscope is now almost an indispensable instrument for the collector of fossil remains; and, in fact, for the cultivator of any natural science. A microscope sufficient for every useful purpose may be obtained, at the price of from seven to twenty guineas, of

Powell, Mr., 24, Clarendon-street, Clarendon-square.

Pritchard, Mr. Andrew, Fleet-street; the author of various useful works on microscopical subjects. Mr. Pritchard's microscope, of from seven to ten guineas, has been purchased by several of my geological friends, and admirably answers the purpose of investigation,

Ross, Mr., 21, Featherstone-buildings, Holborn.

## BRIGHTON.

Thatcher, Mr., West Cliff, King's-road, has often very choice chalk fossils, admirably cleared, and at fair prices. Most of the pebbles cut and set in brooches, and sold by the lapidaries and jewellers in this town, as Brighton productions, are common German moss-agates. The green brooches, called *Brighton aqua marines!* are rolled fragments of wine-bottles. Occasionally good sections of the *Choanites* (see p. 264.) may be obtained: inquire for "*petrified sea-anemones.*"

DOVER.

Moses, Snargate-street; has generally a large collection of Chalk and Marl fossils; his prices are high.

HASTINGS.

Bissenden, Thomas, West-street; Oliver, Elizabeth, 7, Parade: of whom Wealden fossils from the neighbouring cliffs may often be obtained.

LEWES, SUSSEX.

Martin, J., *Mason*, Fisher-street: the usual Chalk fossils from the neighbouring quarries; and polished slabs of Sussex marble, and of Bracklesham Septaria with shells (p. 373.). Fossil wood from Portland. Any collector or Institution having large specimens imbedded in stone to develope, may safely entrust them to Mr. Martin; he was the only person that assisted me in dissecting the Tilgate fossils now in the British Museum, and has become an expert and cautious workman.

MAIDSTONE.

Simmons, T., a well-known dealer; has usually a large collection of the Kentish Green Sand and Chalk fossils.

SHEERNESS.

Hayes, Patrick, Sheppey-street, Blue Town. The usual Sheppey fossils. According to his own list, he has for sale,—petrified whelk-shells, cockles, clams, screws, Nautilus. Fruits, various; as beans, coffee, figs, nuts. Crabs, lobsters, turtles. Fishes' heads, teeth, and spine-bones. His charge for perfect specimens is high; a Nautilus, cut in half and polished, presenting two perfect sections, 25*s.*; if imperfect, 1*s.* or 2*s.* A fish's head, or lobster, 10*s.* to 15*s.*; imperfect examples, 6*d.* to 2*s.*; see p. 898.

#### WARMINSTER.

BAKER, Mr.; dealer in fossils. The Warminster green-sand, and Chalk fossils.

MINERALS.—A complete series of the minerals of Cumberland, comprising specimens of great beauty and interest, can be obtained of JOHN COWPER, Alston, Cumberland. This collector formed one of the finest series I have ever seen, for the Rev. Charles Pritchard, F.R.S.; he may be relied upon for his knowledge and attention, and his prices are very moderate.

## ADVERTISEMENT.

THE Author will feel obliged by any information relating to British localities of organic remains, or interesting geological sites, that will serve to render the "Geological Excursions" more generally useful. Such contributions will be duly acknowledged in the "*Geological Rambles in various Parts of England.*"

# INDEX

OF

# SCIENTIFIC NAMES.

## A.



## B.

O.



P.

V.



W.



X.



Z.

# INDEX OF PLACES.

*** In order to facilitate the reference to places, this Index is inserted; and with the assistance of the Lists of Localities of Fossils, appended to each division of the work, will, it is presumed, enable the reader to refer to the notice of any locality, with but little trouble.

G.



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S.

# GENERAL INDEX.

## A.



## B.



* This work has been completed since the article on Fossil Ichthyology was printed.

D.



E.

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## I.



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## K.



## L.

M.

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Q.



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S.

Z.



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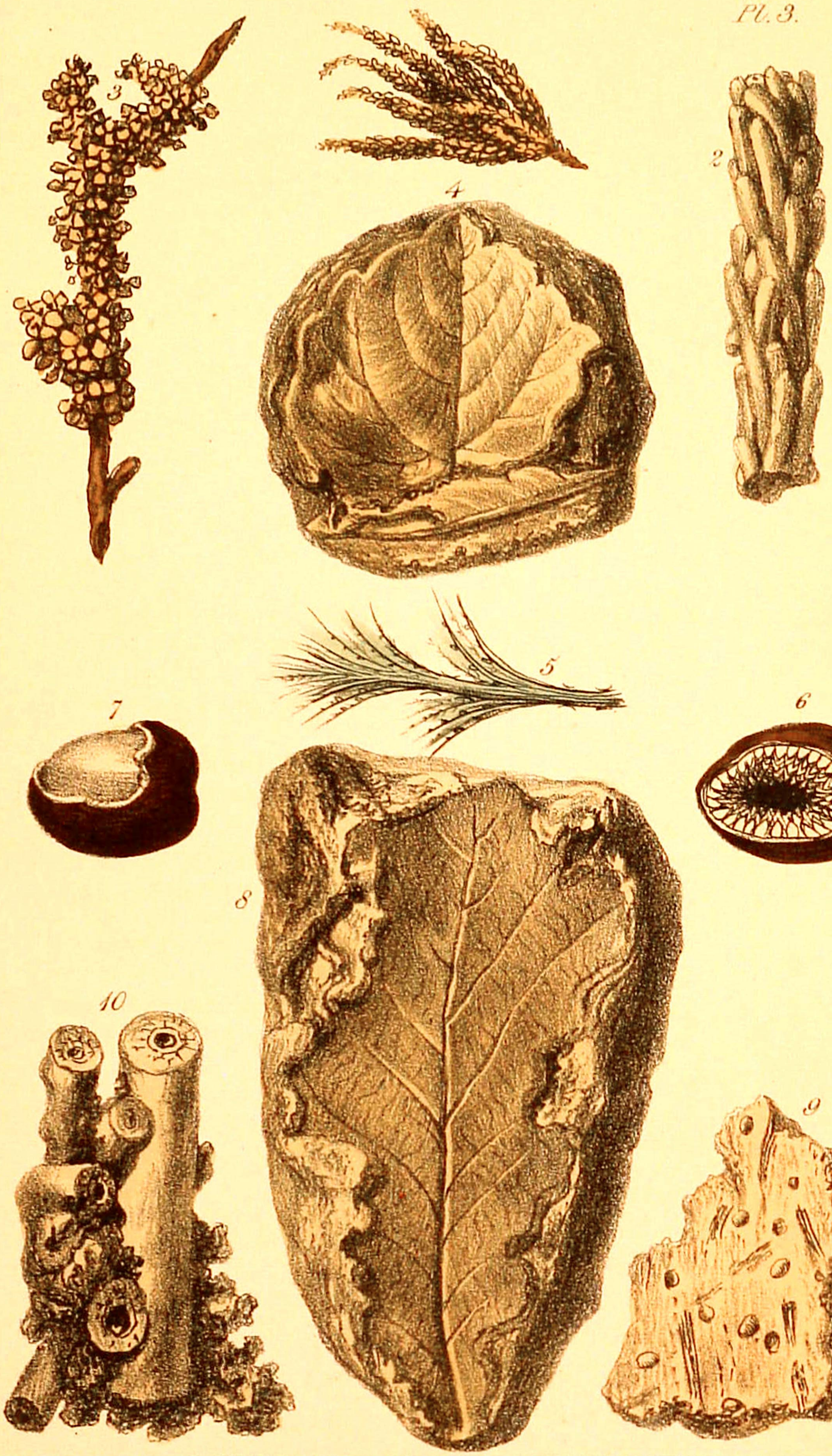
## ERRATA.

A few typographical errors have escaped correction; as, for example, *Ammonidæ*, for *Ammonitidæ;* Auracaria, for *Araucaria; fully*, for *freely* (p. 806.), &c.; but as they are obvious, and do not affect the sense, this general notice will suffice.

R. CLAY, PRINTER, BREAD STREET HILL.

Pl. 3.




J. Dinkel del. G. Scharf lithog.

## DESCRIPTION OF PLATE III.

*Incrustations, and Fossil Plants.*

Fig. 1, 2, 3.—Twigs of Larch and Hawthorn, coated with travertine, from being exposed to the dripping of an incrusting spring; from Russia; see p. 51.

5.—A branch of recent *Chara*, with its fruit, with a thin pellicle of incrustation. Matlock.

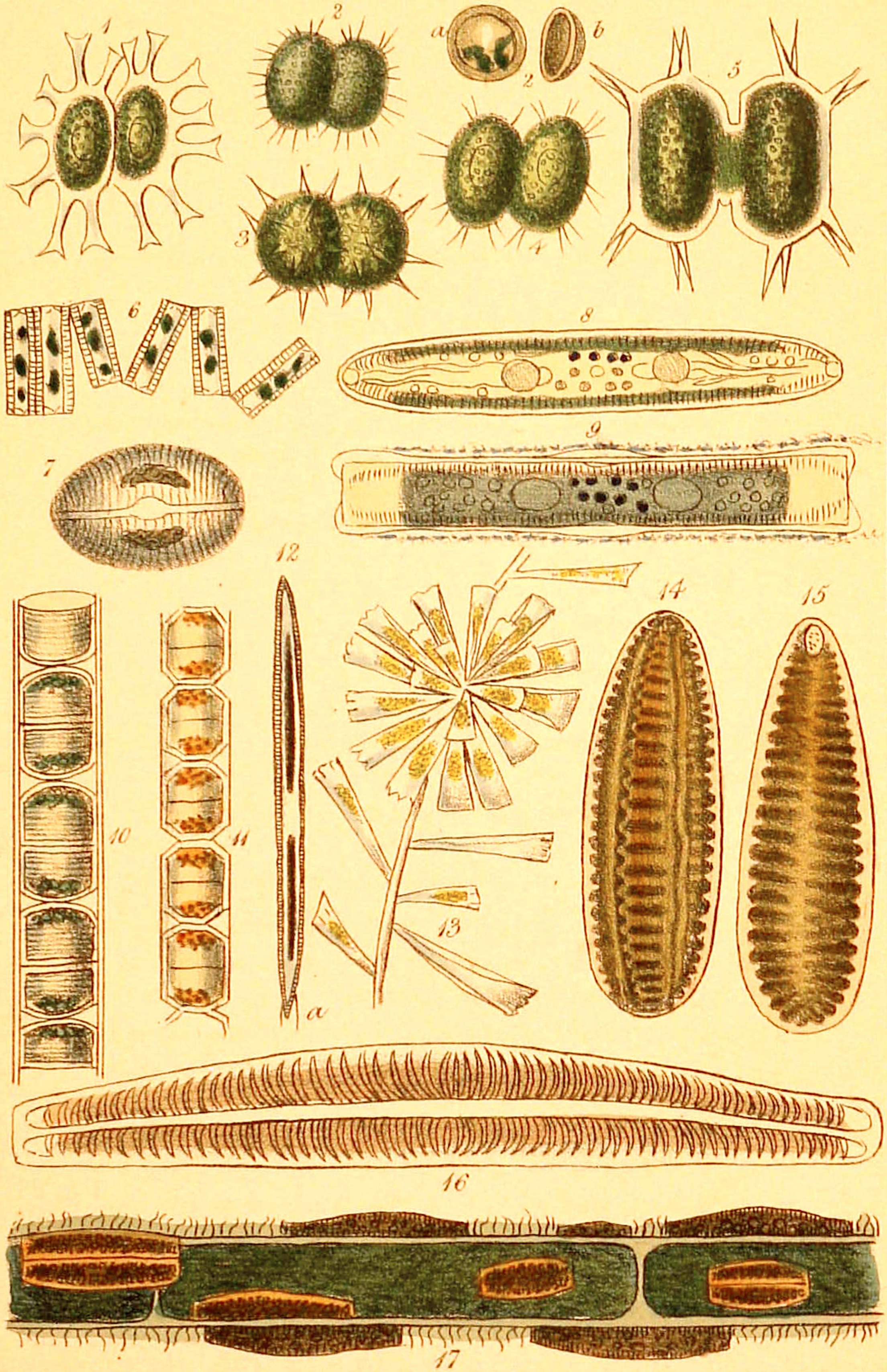
6, 7.—Hazel-nuts, from Belfast Lough: fig. 6 is lined with crystals of calcareous spar; fig. 7 is filled with a solid mass of the same mineral; see p. 83.

4, 8.—Impressions of Dicotyledonous Leaves in Gypseous Marl or Limestone, from Stradella, near Pavia; see p. 195.

9.—Lacustrine, or Fresh-water Limestone, from the Isle of Wight, with stems and seeds of Charæ: slightly magnified; see p. 187.

10.—Encrusted Twigs, from Matlock; the vegetable matter has perished, and left tubular cavities; see p. 51.

Pl. 4.




J. Dinkel del. G. Scharf lithog.

## DESCRIPTION OF PLATE IV.

*Various species of Living Infusoria, to illustrate the nature of Fossil Animalcules.*

*For detailed descriptions, see pages* 217—220.

Figs. 1 to 5.—Various kinds of *Xanthidia:* figs. 2, 3, 4, have been found in a pond on Clapham Common, and fig. 1. living in a pond near Westpoint, United States.

1.—Xanthidium *furcatum:* $\frac{1}{24}$ of a line in diameter.

2.— ———— *hirsutum:* $\frac{1}{36}$.

3.— ———— *aculeatum:* $\frac{1}{24}$.

4.— ———— *fasciculatum:* $\frac{1}{24}$.

5.— ———————— variety of the above.

2*.—Pyxidicula operculata; Carlsbad, Bohemia: $\frac{1}{48}$ of a line in diameter.

6.—Bacillaria vulgaris: $\frac{1}{36}$ of a line in diameter. Pond on Clapham Common.

7.—Cocconeis scutellum: in the Baltic: $\frac{1}{24}$ of a line.

8.—Navicula viridis: $\frac{1}{6}$ of a line. Ponds on Clapham Common.

9.—The same; a side view; showing the currents produced in the water by the animal when in locomotion.

10.—Gaillonella lineata: $\frac{1}{36}$ of a line. Ponds on Clapham Common.

11.—Gaillonella moniliformis: $\frac{1}{72}$ of a line. Berlin.

12.—Synhedra ulna: $\frac{1}{9}$ of a line: the point *a*, marks the pedicle of attachment. Ponds on Clapham and Wandsworth Commons.

13.—Podosphenia gracilis: $\frac{1}{12}$ of a line; attached to a thread of *Calothria*, and having by self-division formed a radiating cluster of individuals. Common in the ditches communicating with the Thames, in Battersea-fields.

## DESCRIPTION OF PLATE IV.—*continued.*

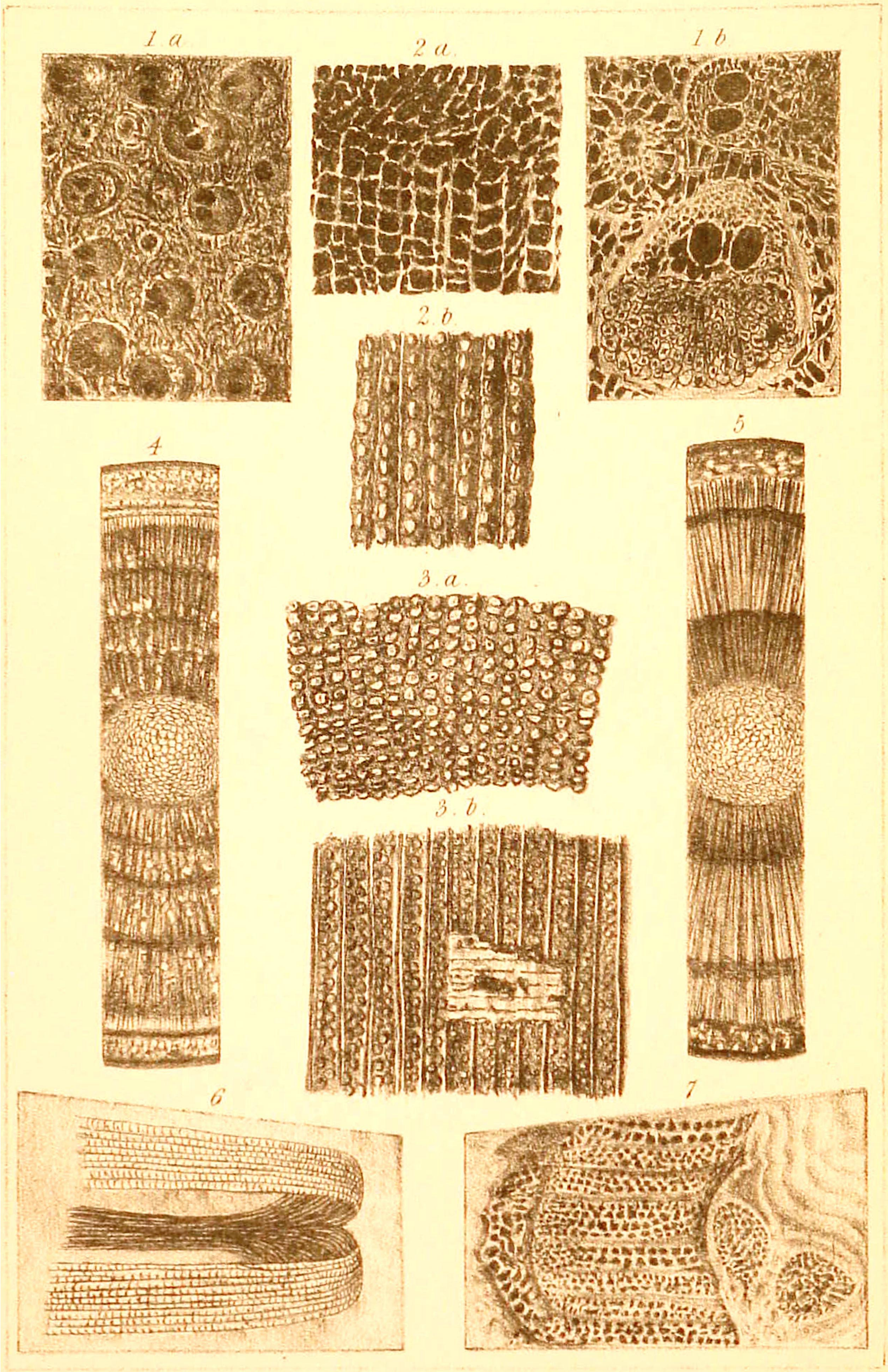
Fig. 14.—Navicula splendida: $\frac{1}{12}$ of a line in diameter.

15.—Lateral view of the same.

16.—Eunotia turgida: $\frac{1}{14}$ of a line (*Ehrenberg*): the empty shell, with sixty-five ribs, viewed laterally.

17.—A group of the same, living: $\frac{1}{20}$ of a line (*Ehrenberg*): a piece of *Conferva rivularis*, beset with these animalcules. The smaller species are *E. Westermanni*.

Pl. 5.




Dinkel. del | Lens Aldous, Zinc

## DESCRIPTION OF PLATE V.

*Illustrative of the Organization of Fossil Vegetables.*

Fig. 1.—Polished transverse section of silicified Monocotyledonous Wood, from Antigua; p. 173.

1*a*.—Magnified 20 times linear.

1*b*.—Magnified 75 times linear.

2*a*.—Transverse section of silicified Coniferous Wood (*Abies Benstedi*) from the Kentish Rag, Iguanodon quarry, near Maidstone; × 120 linear; p. 166.

2*b*.—Vertical or longitudinal section of the same, × 250 linear.

3*a*.—Transverse section of calcareous coniferous wood, from Willingdon, Sussex, × 80 linear; p. 166.

3*b*.—Longitudinal section of the above, × 120 linear.

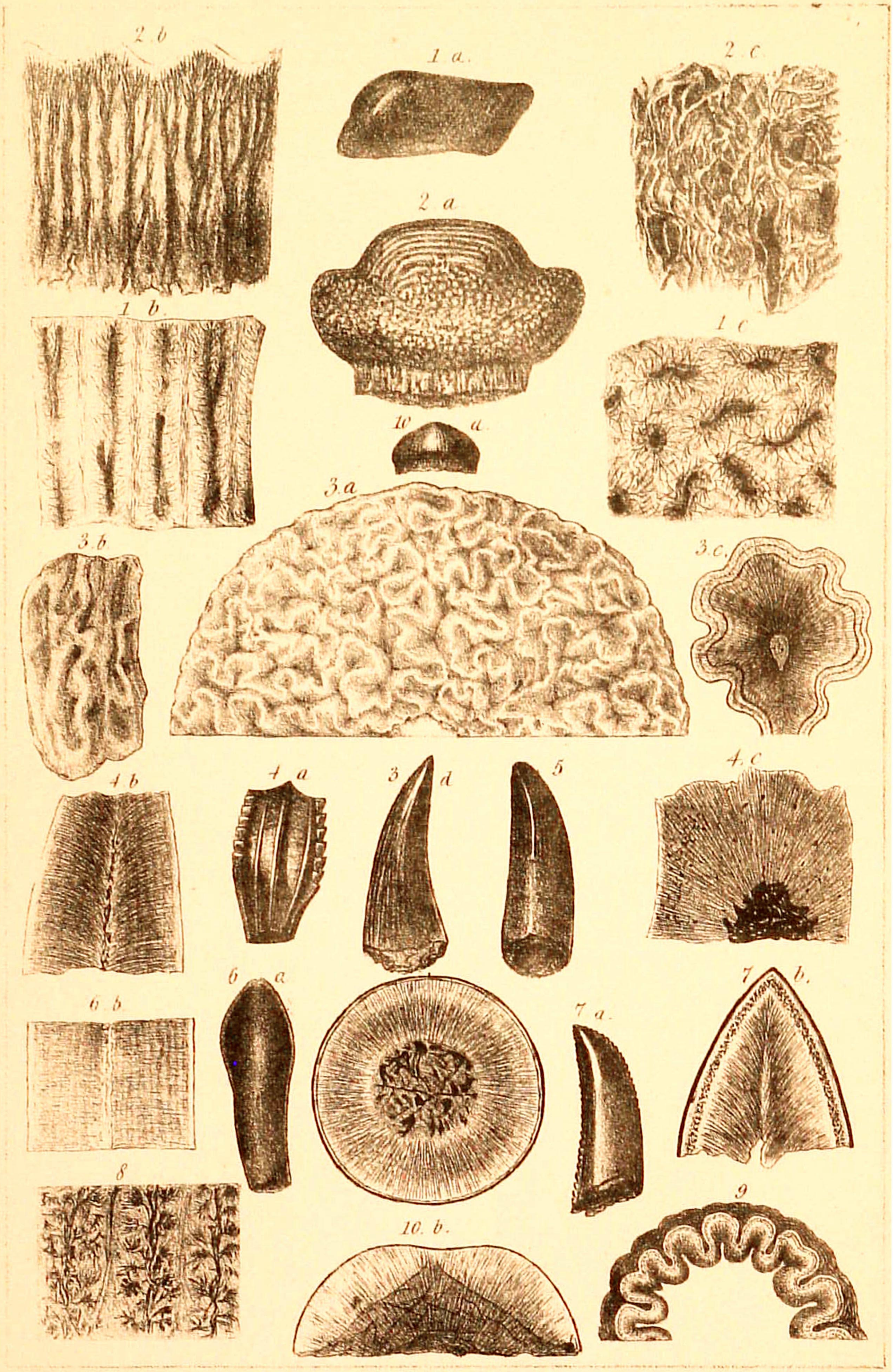
4.—Slice of a transverse section of a recent Dicotyledonous Stem; showing, 1st, Pith or medullary column, occupying the centre; 2d, Four bands of woody layers, separated by condensed lines of elongated tissue in series, and having large regular openings of vessels, with numerous medullary rays running continuously from the central pith to the bark; 3d, the bark. (*From Mr. Witham.*)

5.—Slice of a transverse section of a recent gymnospermous phanerogamic stem (of a *Cycas*), having a central pith, with woody layers separated by a condensed line, and consisting of elongated cellular tissue, arranged in a regular series; medullary rays, and bark. (*From Mr. Witham.*)

6.—Bundles of vascular tissue in *Stigmaria ficoides*, × 12 linear. See p. 143.

The two strands of vessels that appear as if on the surface (and are of a looser texture) are part of the vascular tissue of the stem, and become inflected (that is bent over), and give rise to a band of vessels (the darker band seen between the above), that passes towards the bark or cortical covering.

Pl. 6




[illegible] del

Lens Aldous, Zinc.

## DESCRIPTION OF PLATE VI.

*Illustrative of the structure of Fossil Teeth.*

Fig. 1[a].—Tooth of *Psammodus porosus*, from the Oolite. See p. 617.

1[b].—Vertical section, a portion × 75 linear.

1[c].—Transverse section of the same, × 75.

2[a].—Tooth of *Ptychodus polygurus*, from the Chalk, near Lewes. See p. 616.

2[b].—Portion of longitudinal section, × 20.

2[c].—Portion of transverse section, × 20.

3[d].—Tooth of the *Labyrinthodon Jægeri*, from the New Red sandstone near Wirtemberg; half the natural size: the specimen presented by Dr. Jæger. See p. 786.

3[a].—A moiety of a transverse polished section, × 20.

3[b].—Portion of a vertical section near the apex, × 20.

3[c].—One of the anfractuosities of fig. 3[a] × ×.

4[a].—Crown or upper portion of a tooth of a young *Iguanodon* from Tilgate Forest. See p. 743.

4[b].—Portion of a vertical section of the above, × 20.

4[c].—A small portion of a transverse section of the same, × 20.

5.—Tooth of *Goniopholis*, Tilgate Forest: half the natural size. See p. 721.

6[a].—Tooth of a reptile (probably of the *Hylæosaurus*) from Tilgate Forest; half the natural size. See p. 738.

6[b].—Portion of a vertical section of the same, × 20.

7[a].—Tooth of *Megalosaurus* from Tilgate Forest. See p. 733.

7[b].—Portion of a vertical section of the same, × 10.

8.—A very small portion of a vertical section of a tooth of *Dendrodus*, (*Professor Owen*). See p. 653.

9.—Portion of a transverse section of the base of a tooth of *Ichthyosaurus*, × 20. (*Professor Owen*). See p. 710.

10[a].—Tooth of *Lepidotus*, Tilgate Forest. See p. 639.

10[b].—The upper figure is a transverse section, and the lower a vertical section of the same, × 20.