A GUIDE

TO THE

FOSSIL REPTILES AND FISHES

IN THE DEPARTMENT OF

GEOLOGY AND PALÆONTOLOGY

IN THE

BRITISH MUSEUM (NATURAL HISTORY),

CROMWELL ROAD, LONDON, S.W.

WITH 165 ILLUSTRATIONS.

PRINTED BY ORDER OF THE TRUSTEES.

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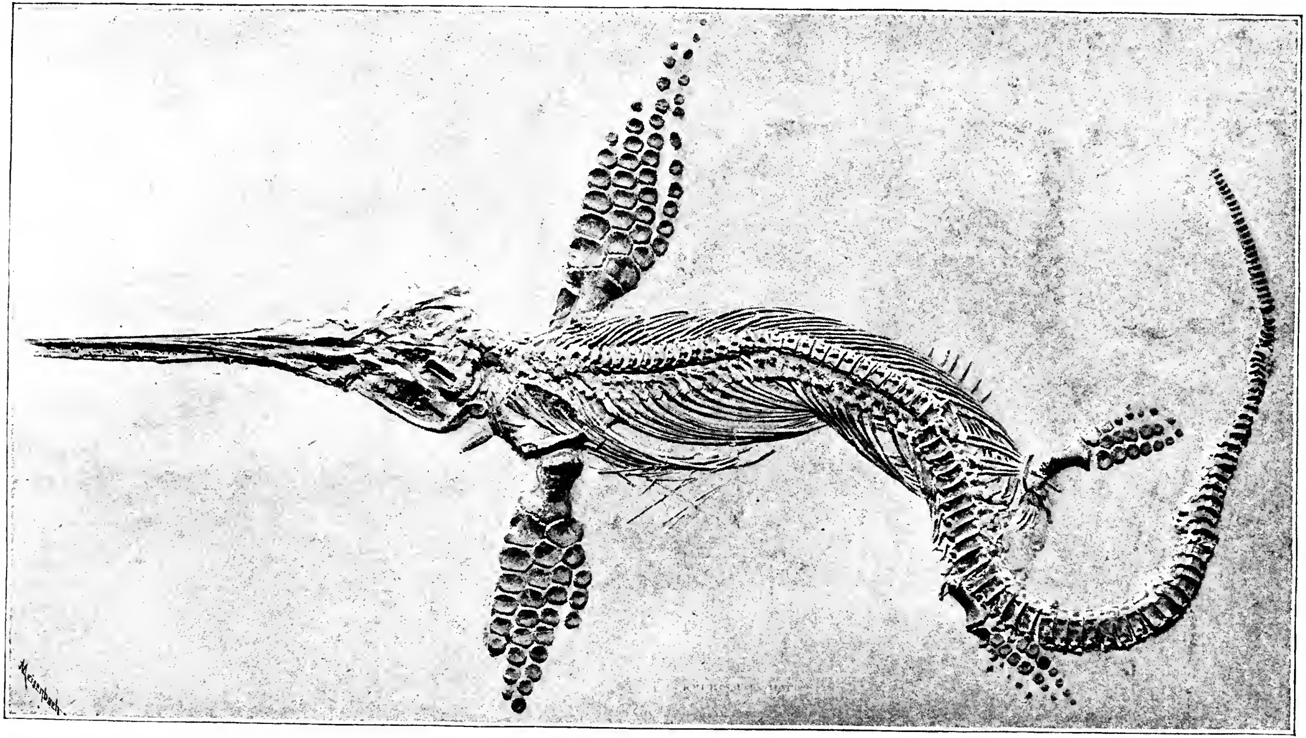

ICHTHYOSAURUS TENUIROSTRIS (Conybeare).
From the Lower Lias of Street, Somerset.

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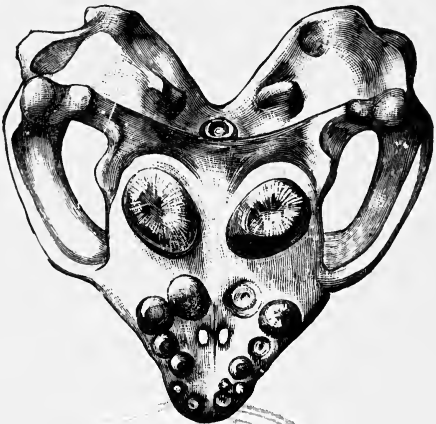

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PREFACE.

THE First Edition of this Guide was issued, without illustrations, on the 19th April, 1881; the second in 1882, illustrated with thirty-one wood engravings; a third, slightly altered, appeared in 1884. A fourth Edition, almost wholly re-written, with many fresh illustrations, appeared in 1886, and a fifth, with only a few alterations, in 1888. The sixth Edition appeared in April, 1890, and 3,000 copies were sold up to October, 1895. Of these six editions, altogether 18,000 copies have been issued.

The publication of Mr. R. Lydekker's Museum Catalogues of the "Fossil Reptilia and Amphibia," Parts I–V. (1888–90), and Mr. Arthur Smith Woodward's Catalogue of the Fossil Fishes, Parts I–III. (1889–95), and the very numerous and important additions made to the exhibited series of specimens have necessitated the re-arrangement of a great part of these Collections, and also changed the plan of the Guide.

The writer is largely indebted to the authors of Nicholson's and Lydekker's "Palæontology" (Vol. II., "Vertebrata," by R. Lydekker), from which numerous notes and extracts have been made in the compilation of this Guide. The part relating to the Fossil Fishes has been entirely re-written by Mr. Arthur Smith Woodward. Mr. C. W. Andrews has also obligingly assisted in the preparation of this work.

HENRY WOODWARD.

Department of Geology,

8th April, 1896.

TABLE OF STRATIFIED ROCKS.

Periods.		SYSTEMS.	FORMATIONS.	LIFE-PERIODS.
CAINOZOIC.	Quaternary.	RECENT	Terrestrial, Alluvial, Estuarine, and Marine Beds of Historic, Iron, Bronze, and Neolithic Ages	Dominant type, Man.
		PLEISTOCENE (250 ft.)	Peat, Alluvium, Loess Valley Gravels, Brickearths Cave-deposits Raised Beaches Palæolithic Age Boulder Clay and Gravels	
	Tertiary.	PLIOCENE (100 ft.)	Norfolk Forest-bed Series Norwich and Red Crags Coralline Crag (Diestian)	Dominant types, Birds and Mammals.
		MIOCENE (125 ft.)	Œningen Beds Freshwater, &c.	
		EOCENE (2,600 ft.)	Fluvio-marine Series (Oligocene) Bagshot Beds } (Nummulitic Beds) London Tertiaries } (Nummulitic Beds)	
SECONDARY OR MESOZOIC.		CRETACEOUS (7,000 ft.)	Maestricht Beds Chalk Upper Greensand Gault	
		NEOCOMIAN	Lower Greensand Wealden	
		JURASSIC (3,000 ft.)	Purbeck Beds Portland Beds Kimmeridge Clay (Solenhofen Beds) Corallian Beds Oxford Clay Great Oolite Series Inferior Oolite Series Lias	Dominant type, Reptilia.
		TRIASSIC (3,000 ft.)	Rhætic Beds Keuper Muschelkalk Bunter	
PRIMARY OR PALÆOZOIC.		PERMIAN or DYAS (500 to 3,000 ft.)	Red Sandstone, Marl } Zechstein Magnesian Limestone, &c. } Zechstein Red Sandstone and Conglomerate Rothliegende	Dominant type. Fishes.
		CARBONIFEROUS (12,000 ft.)	Coal Measures and Millstone Grit Carboniferous Limestone Series	
		DEVONIAN & OLD RED SANDSTONE (5,000 to 10,000 ft.)	Upper Old Red Sandstone Devonian Lower Old Red Sandstone	
		SILURIAN (3,000 to 5,000 ft.)	Ludlow Series Wenlock Series Llandovery Series May Hill Series	Dominant type, Invertebrata.
		ORDOVICIAN (5,000 to 8,000 ft.)	Bala and Caradoc Series Llandeilo Series Llanvirn Series Arenig and Skiddaw Series	
		CAMBRIAN (20,000 to 30,000 ft.)	Tremadoc Slates Lingula Flags Menevian Series Harlech and Longmynd Series	
		EOZOIC—ARCHÆAN (30,000 ft.)	Pebidian, Arvonian, and Dimetian Huronian and Laurentian	

Range of Invertebrata and Plants in time.

Range of Fishes in time.

Range of Amphibia and Reptilia in time.

Footprints of Birds?—Range of Birds in time.

Range of Mammalia in time.

DEPARTMENT OF

GEOLOGY AND PALÆONTOLOGY.

INTRODUCTION.

Nearly every city has within its bounds some relics of earlier times, when a more ancient people occupied the same spot.

Thus below modern London we find various layers of accumulated soil, each marked by tokens of former times. In one we find the charred relics of the wooden buildings which preceded the more modern brick and stone houses; beneath this are found weapons, coins, and pottery, telling of Norman and Saxon times. More than 20 feet down we come upon the relic-bed of Roman London, and in some parts *two* Roman *periods* have been recognised with remains of buildings at different depths. At a still lower level, along the course of the ancient Wall-brook, remnants of pile-dwellings have been discovered, which were probably occupied by an earlier British race.

In the ancient gravels of the Thames Valley, both beneath and around London, stone implements, left by a yet earlier people, have been frequently met with, associated with bones and teeth of the Mammoth.

If in a similar manner we investigate those larger layers of Chalk and Limestone, Sandstone, Clay, or Slate, composing the Earth's crust, we not only find that they rest upon one another, so that we can judge of their relative age by the order of their superposition, but that, like the layers of soil below London, they are often full of relics which tell of the former inhabitants that lived, flourished, and died out, to be succeeded by another race which have in their turn shared the same fate.

Geology deals with the Earth, the composition of the various strata, or layers, of which it consists, their present and former extent, and the physical conditions under which they were deposited, and the changes they have since undergone.

Palæontology deals with the remains of ancient life found in the various layers, and strives, by comparison with living forms, to restore the successive faunas and floras which have passed away, and to trace by those relics their past distribution, and thus to show the evolution of life on the earth from the earliest times to our own.

So many good books on Geology and Palæontology have been published * that it is not necessary to give in such a guide-book as the present a treatise on the science, but merely to explain that the Vertebrata in the Galleries are arranged according to their zoological classes, orders, and families (so far as these can be ascertained); and upon the label to each is placed its name, its geological position, and the locality whence it was derived. In the Invertebrata and Plants each class is also grouped chronologically in order, from the latest deposits to the earliest in which it occurs.

Whenever a specimen has been figured and described in a scientific work, a green disk is affixed to it, and a reference is given to the author, and to the name and date of the work where it was published.

Explanatory labels and illustrations have been introduced in many instances, to afford fuller information to visitors respecting the objects exhibited.

A plan of the Gallery will be found affixed to the wall in each room, which will serve to show the general arrangement of the cases and their contents. The small Table of Strata, on p. xii, is given to indicate the range in time of the great groups of Mammals, Birds, Reptiles, Fishes, Invertebrates, and Plants.

H. W.

* *See* specially "Manual of Palæontology," by Prof. H. Alleyne Nicholson and R. Lydekker, in 2 vols. (3rd Edition). Wm. Blackwood and Sons, Edinburgh and London. 1889.

GUIDE TO THE DEPARTMENT

OF

GEOLOGY AND PALÆONTOLOGY.

REPTILIAN GALLERY.*

Reptilian Gallery. Wall-case, No. 1.

This Gallery is devoted to the exhibition of the remains of fossil Reptilia, a class which includes the Tortoises and Turtles, Snakes, Lizards, Crocodiles, and a large number of extinct forms, the exact zoological position of many of which we can only judge by analogy. Like the Mammalia, the Reptilian class lived both on land and in the water; some being evidently fitted for terrestrial locomotion by their well-developed legs; others, as shown by their paddle-shaped limb-bones, must have passed their entire existence in the water. One group, now extinct, possessed, like the Bats and the Birds, the power of flight.

Class 3.—REPTILIA.

Order I.—PTEROSAURIA (Winged-Lizards).

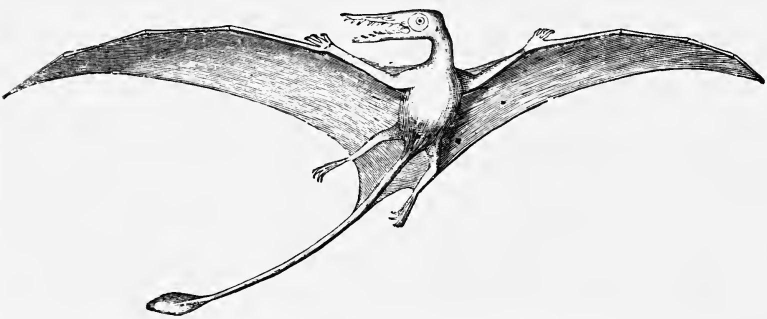


Fig. 1.—Restoration of *Rhamphorhynchus Muensteri*, Goldfuss (after Marsh); one-seventh natural size, from the Lithographic Stone, Eichstädt, Bavaria.

Pterodactyles. Wall-case, No. 1, Table cases, Nos. 1 and 2.

In Wall-case No. 1, and in Table-cases Nos. 1 and 2, are placed the fossil remains of this extinct group of "Flying Lizards," or Pterodactyles. These animals had the centra of the vertebræ hollow in front; they possessed a broad *sternum* or "breast-bone," with a median ridge or keel, similar to that of birds; the jaws were usually armed with teeth fixed in sockets. The fore-limb had a short humerus, a long radius and ulna, and

* Galleries 3, 4, and 5 on Plan facing p. 102.

Flying Lizards.

one of the fingers of the hand was enormously elongated to give support to the wing-membrane (*patagium*), which was attached to the sides of the body, the arm, and the long finger, and also to the hind-limb and tail. The other fingers of the hand were free and furnished with claws. The wing-membrane appears to have resembled that of the Bat, being destitute of feathers. The caudal series of vertebræ in some genera (as in *Rhamphorhynchus*) was greatly elongated and stiffened with slender

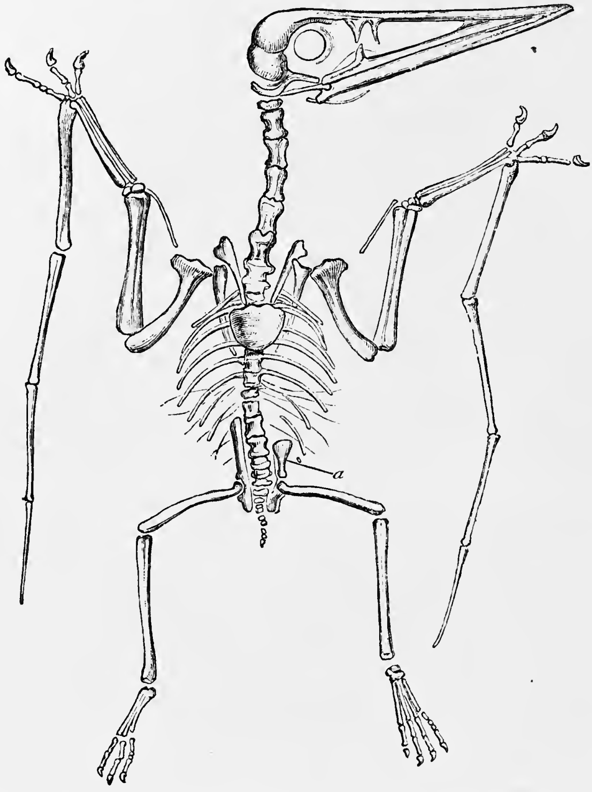


FIG. 2.—The nearly entire skeleton of *Pterodactylus spectabilis* (Meyer), from the Lithographic Stone, Upper Jurassic, Eichstädt, Bavaria. *a* is the pubis; on the right side the ilium is exposed (figured nat. size).

Wall-case, No. 1.

ossified fibres (Figs. 1 and 5). The bones were pneumatic (*i.e.*, filled with large air-cavities), the walls of the bones being very thin, and their substance very hard and compact, thus combining strength with lightness.

Numerous remains of nearly perfect Pterodactyles, with both long and short tails, and varying greatly in size, have been obtained from the Solenhofen Limestone in Bavaria—others occur in the Great Oolite at Stonesfield, near Oxford, and in the Lias formation, Lyme Regis, Dorset. The most remarkable

Pterodactyles.

Wall-case, No. 1.

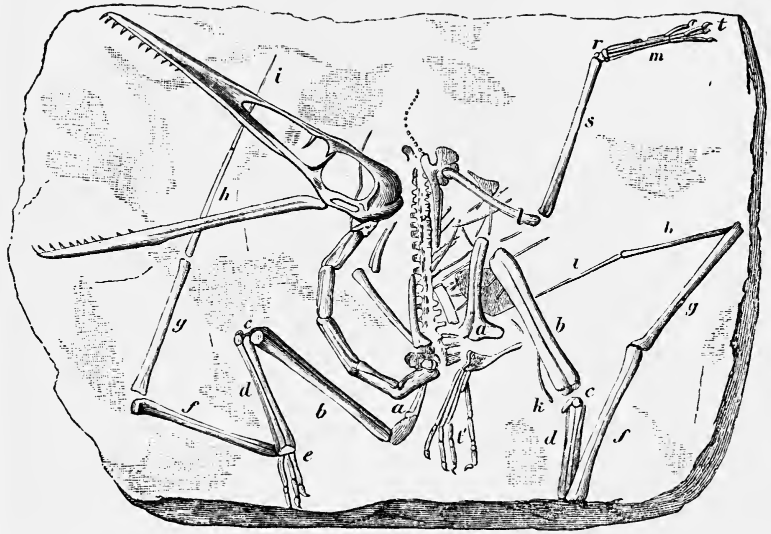


Fig. 3.—The almost complete skeleton of *Pterodactylus antiquus* (Sömmerring), from the Lithographic Stone, Eichstädt, Bavaria (½ nat. size). *a*, humerus; *b*, radius and ulna; *c*, carpus; *d*, metacarpus; *e*, clawed digits; *f*, *g*, *h*, *i*, phalangeals of ulnar digit; *k*, rib; *l*, femur; *s*, tibia; *r*, tarsus; *m*, metatarsals; *t*, *t′*, phalangeals of pes.

Table-case, No. 1.

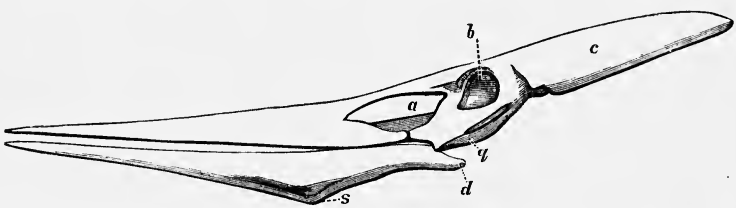


Fig. 4.—Left lateral view of skull of *Pteranodon longiceps* (Marsh), from the Cretaceous of North America ($\frac{1}{12}$ nat. size). *a*, preorbital vacuity; *b*, orbit; *c*, supraorbital crest; *d*, angle of mandible; *q*, quadrate; *s*, symphysis. (Not represented in the Collection.)

of these English examples is the *Dimorphodon macronyx* from the Lias of Lyme, which had a large head, the jaws armed with lancet-shaped teeth, a long tail, and well-developed wings. The skull was 8 inches in length, and the expanse of the wings about 4 feet (*see* Fig. 5).

Dimorphodon.

Wall-case, No. 1.

Many remains have been discovered by Prof. Marsh in the Chalk of North America. One singular form, named by him

Pterodactyles. Wall-case, No. 1.

Pteranodon, had no teeth in its jaws, which were a yard in length, sharp-edged and pointed, and were probably encased in a horny sheath like the beak of a stork or heron (*see* Fig. 4).

Table-case, No. 1.

The Flying Lizards of the Chalk and Greensand attained even a larger size —but their remains are all very fragmentary. For example, some detached vertebræ of the neck of one species have been found in the Cambridge Greensand, measuring 2 inches in length, and portions of humeri 3 inches broad. Such bones give evidence of a flying lizard having probably an expanse of wings of from 18 to 20 feet. The Pterodactyles of the Chalk of Kent were nearly, if not quite, as large.

The smallest species of Pterodactyle from Solenhofen was not larger than a sparrow (*see* Table-case No. 1). These singular flying reptiles do not appear to have lived longer than the period of time represented by the deposition of the strata from the Lias formation to the Chalk, their remains being confined to rocks of the Secondary, or Mesozoic age. They are now entirely extinct.

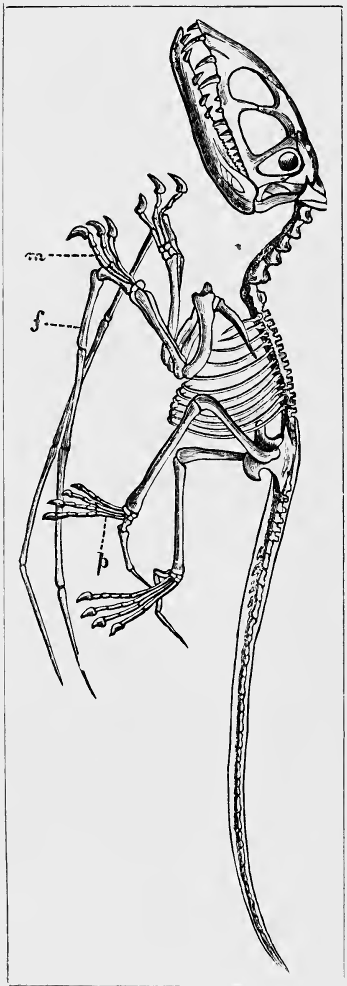


Fig. 5.—Skeleton of *Dimorphodon macronyx* (Owen), L. Lias, Lyme Regis, Dorset. m = manus; f = wing-finger; p = foot. Atout $\frac{1}{8}$.

Order II.—CROCODILIA. (Crocodiles.)

Crocodiles. Wall-case, No. 2, and Table-cases, Nos. 9 to 13.

The Crocodilia, except in one or two instances (which are placed in Wall-case No. 2, and in Table-cases Nos. 9–13) have the body covered with a thick layer of oblong bony plates or scutes, pitted on the surface, and covered with a horny substance. They have a single row of pointed and subconical or laterally compressed teeth in distinct sockets, which are continually being renewed from below. The skull is relatively large in proportion to the body, and is usually much depressed; its component bones are firmly united and generally have a characteristic sculpture on their external surface. The palatines and pterygoids unite in the middle line and thus close the palate, and very frequently one or both of these paired bones develop inferior plates, which meet beneath the narial passages. The quadrate is tightly wedged in

Crocodilia. Wall-case, No. 2.

Table-cases Nos. 9 to 13.

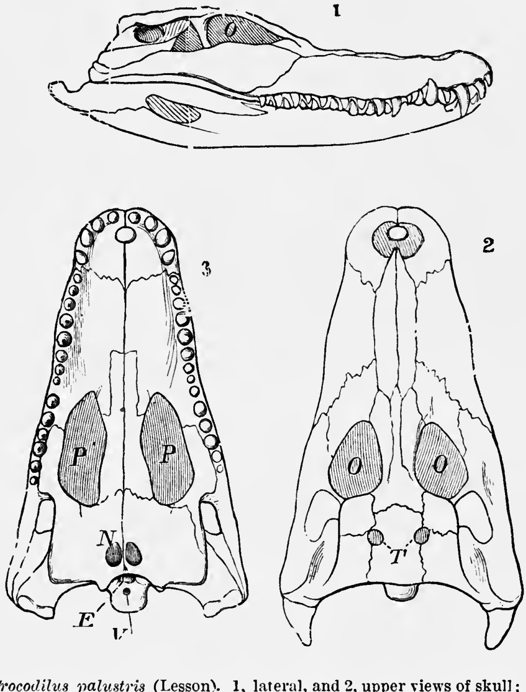


FIG. 6.—*Crocodilus palustris* (Lesson). 1, lateral, and 2, upper views of skull; 3, palatal view of cranium; *E*, aperture of median eustachian canal; *N*, posterior nares; *O*, *O*, orbits; *P*, *P*, palato-pterygoid vacuities; *T*, supra-temporal fossæ; *V*, basi-occipital. The figures are much reduced. Common, living in Western India. Fossil in the Pleistocene deposits of the Narbada Valley, India.

among the adjacent bones; the tympanic cavities usually communicate with the mouth by three eustachian canals; the mandibular symphysis unites by suture; there are, as a rule, no ossifications in the sclerotic of the eyeball. There is almost invariably a lateral vacuity in the mandible. The vertebræ of these reptiles are cup-shaped or concave at both ends, as in *Teleosaurus*; or concave in front and convex behind, as in the Crocodile from Sheppey (Fig. 7) and in all living Croco-

Crocodilia.
Wall-case, No. 2.

diles. Professor Owen has constituted two groups, based on these modifications of the vertebræ. The Crocodiles belong to the Procœlian section (vertebræ concave in front), and are divided into a *brevirostrine*, or short-snouted section, containing the Alligator, the Crocodile, and the Tertiary genus *Diplocynodon;* and a *longirostrine*, or long-snouted section, embracing the Garials, *Tomistoma*, *Thoracosaurus*, and *Rhamphosuchus.*

Table-cases, Nos. 10 to 11.

The Amphicœlian section (vertebræ concave at both ends), embraces *Hylæochampsa*, also a second brevirostrine section including *Theriosuchus*, *Goniopholis*, *Nannosuchus*, and *Oweniasuchus*, and a second longirostrine section for *Pholidosaurus* and *Petrosuchus*, all from the Wealden and Purbeck beds.

Table-case, No. 12.
Belodon.
Wall-case, No. 2.
Table-case, No. 13.

The older secondary forms belong to the Amphicœlian section as *Dacosaurus*, *Metriorhynchus*, *Teleidosaurus*, *Machimosaurus*, *Pelagosaurus*, *Steneosaurus*, and *Teleosaurus*. The earliest of the Crocodilian reptiles is named *Belodon* (Fig. 8); it had long and pointed slightly-curved teeth, longitudinally grooved, and

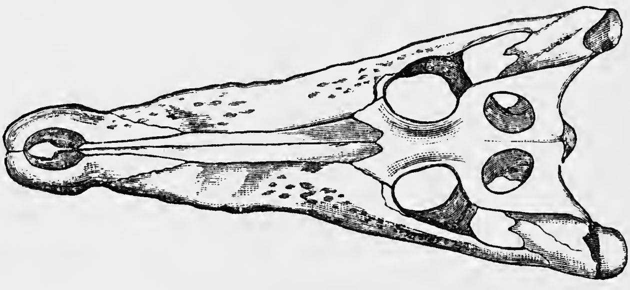


FIG. 7.—*Crocodilus Spenceri* (Buckland). Upper view of skull restored, from the London Clay of Sheppey (about ⅕ nat. size).

elongated jaws like the modern Garials; the other, named *Stagonolepis*, resembled the existing Caimans, but with an elongated skull like the Garials; the body was covered by bony scutes. Both these reptiles are from the Trias, the former from Stuttgart, Germany; the latter from Elgin, Scotland. In the Oolitic and Liassic series the old type of long and slender-jawed Teleosaurs and Steneosaurs (Figs. 9 and 11), with strong bony scutes, was abundantly represented.

Wall-case, No. 2.
Geosaurus.

Here are exhibited the type specimens of *Geosaurus*, from the lithographic stone (Upper Oolite) of Solenhofen, Bavaria. Baron Cuvier inferred, from the form and structure of its skull, that *Geosaurus* held an intermediate place between the crocodiles and the monitors, but was more nearly related to the latter. The orbits are large and the eyes were protected by bony sclerotic plates, like those of *Ichthyosaurus*. It had

A

B

C

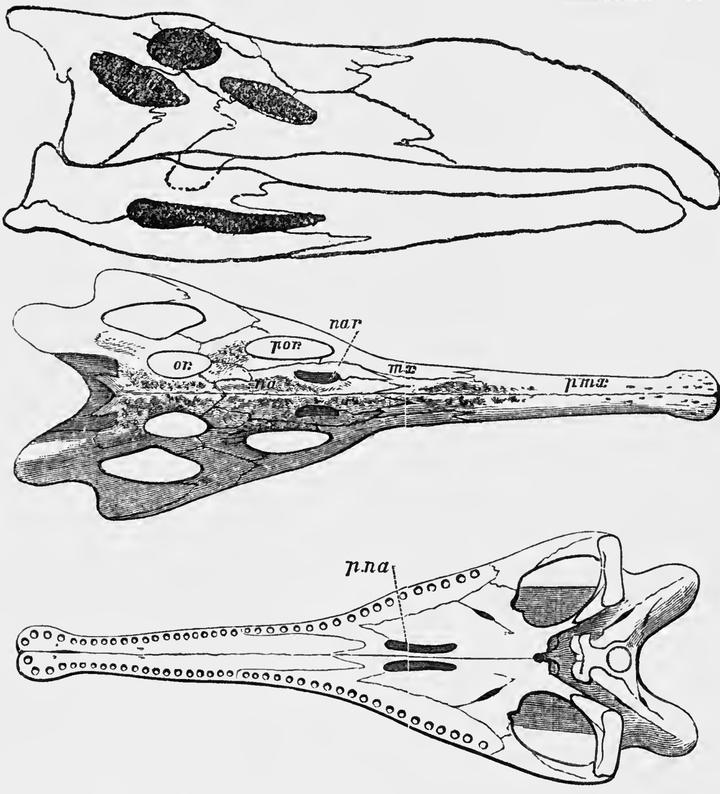


Fig. 8.—*Belodon Kapffi* (Meyer); from the Keuper, Upper Trias, Stuttgart, Wurtemberg. A, lateral view of skull; B, upper view of skull; C, palatal aspect of same; *pmx*, premaxilla; *mx*, maxilla; *na*, nasal; *nar*, nares; *or*, orbit; *por*, preorbital vacuity: *pna* posterior nares (greatly reduced).

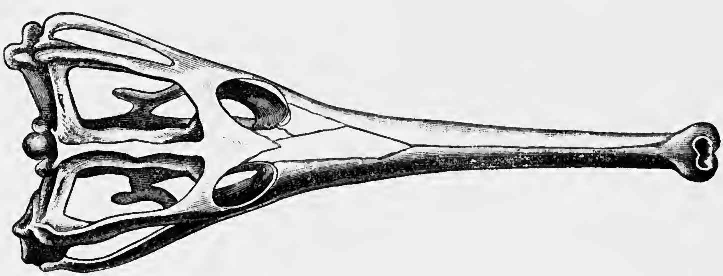


Fig. 9.—Upper view of cranium of *Steneosaurus Heberti* (E. Geoffroy); from the Lower Oxfordian of Normandy (about $\frac{1}{12}$ nat. size).

was herbivorous and its food was probably succulent vegetation. There are no examples of *Diplodocus* at present in the Collection.

Cetiosaurus, or "Whale Lizard."

The *Cetiosaurus*, or "Whale-Lizard," thus named by Sir Richard Owen, from some resemblance in the form and structure of the posterior vertebræ to those of a whale (it must be borne in mind that the Cetiosaurs have really *no affinities* to the whales in any way whatever, save in name!) is another genus of these huge Saurians, whose remains are found in our own island, and of which three species are recorded, the earliest in geological time being the *C. longus* (Owen). Of this species a large portion of a skeleton of the same animal was discovered in 1870, in the Great Oolite at Enslow Bridge, near Oxford, and is preserved in the Oxford University Museum; but plaster-casts of the large bones of the extremities are placed in the case. The femur is $5\frac{1}{2}$ ft. long, and the humerus 4 ft. 3 inches. The anterior vertebræ are large, with cup and ball articulations, they have large cavities in the centra, and are buttressed like those of *Ornithopsis*, an allied genus. A huge arm-bone (humerus) nearly 5 ft. long, from the Kimmeridge Clay, Weymouth, has been referred to this genus, under the name of *C. humero-cristatus*; it is at present the only evidence of the species known. *C. brevis*, from the Wealden of Sussex and the Isle of Wight, is represented by caudal and dorsal vertebræ, &c., including the original specimens from Dr. Mantell's collection, upon which the genus was founded.

Ornithopsis.

Wall-case, No. 3.

Here are exhibited a series of vertebræ and other remains of a huge Dinosaur, named *Ornithopsis Hulkei* (Seeley), obtained from the Wealden formation, Brixton, Isle of Wight.

Ornithopsis was remarkable for the extreme lightness in construction of the bones of its neck and back, combined with great strength. A single dorsal vertebra had a centrum 10 inches long, and 25 inches in circumference at the front or convex end, whilst it measured in height to the summit of the dorsal spine 25 inches; and in breadth across the transverse processes 19 inches. A single centrum of one of the cervical or neck vertebræ measures 32 inches in length.

The centrum of each vertebra is composed of highly cellular bony tissue (like the frontal portion of the skull of the elephant), and has a large cavity on each side. The dorsal and cervical vertebræ are opisthocœlous (*i.e.*, hollow behind, and convex in front), and each has articulations for a double-headed rib. The spinous processes are convex, and greatly developed, being rendered at the same time both extremely light and strong by struts and buttresses and thin sheets of bone, with large and deep recesses between. The pelvis and several vertebræ of another very large species, *Ornithopsis Leedsi*, obtained by Mr. Leeds from the Oxford Clay of Peterborough, are exhibited in the same case.

Brontosaurus.

The discovery of the entire remains of a huge Dinosaur in America, which when alive was nearly, or quite, fifty feet in length, named by Prof. Marsh, *Brontosaurus*, with dorsal

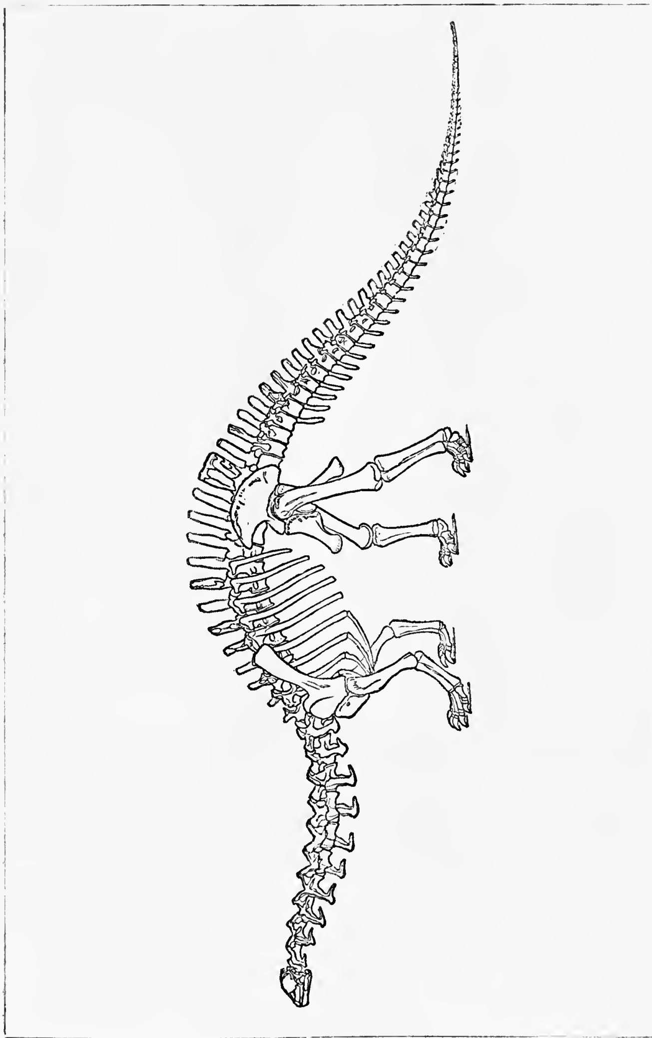


Fig. 13.—Restoration of *Brontosaurus excelsus*, (Marsh), from the Jurassic formation of Colorado, N. America ($\frac{1}{150}$ nat. size). (Not represented in the Collection.)

vertebræ constructed upon the same type as *Ornithopsis*, fully confirms the accuracy of the conclusions arrived at by Prof. Seeley and Mr. Hulke as to the affinities of the latter animal.

Ornithopsis. Wall-case, No. 3.

It seems almost certain that the detached tooth described as *Hoplosaurus armatus*, and the cervical and dorsal vertebræ and pelvis, described under the names of *Ornithopsis Hulkei* and *O. eucamerotus*, are referable to the same form. The head in *Brontosaurus*, with which genus *Ornithopsis* has been compared, was very diminutive in comparison with the size of its huge vertebræ and limb-bones (*see* Fig. 13).

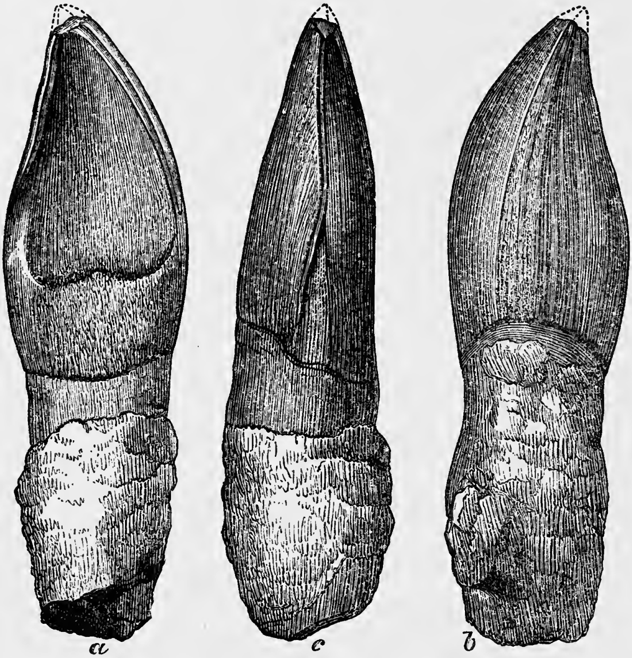


Fig. 14.—(*a*) inner, (*b*) outer, (*c*) profile views of a tooth of *Hoplosaurus armatus* (Gervais), from the Wealden of the Isle of Wight, ½.

Pelorosaurus.

Pelorosaurus, another large land Saurian of the Wealden period, is referred to this sub-order. It probably exceeded in size the largest Iguanodons, and is represented in the Collection by the humerus, which is 52 inches in length.

Another humerus noticed above (p. 10) as having been referred to *Cetiosaurus humerocristatus*, by Hulke, probably belongs to this same genus. An imperfect vertebra from the Oxford Clay, near Peterborough, also may be referred to another species of this genus, and is remarkable for its large size.

Wall-case, No. 3.

In the Southern hemisphere these gigantic Dinosaurs were also found. In the same case are exhibited vertebræ and portions of limb-bones of an enormous species, *Bothriospondylus mada-*

gascariensis from the Jurassic rocks of Madagascar. From S. America a few vertebræ of *Titanosaurus australis*, from the Cretaceous rocks of Patagonia, are exhibited.

SUB-ORDER 2.—**Theropoda** (Beast-footed).

The THEROPODA hold an intermediate position between the Sauropoda and the Ornithopoda, although more nearly allied to the former. In the structure of the teeth, the form of the femur, the occasional presence of only two sacral vertebræ, and in the form of the quadrate bone, certain genera approach more nearly to the Crocodilia than even do the Sauropoda; although in their hollow limb-bones they agree with the **Wall-case. No. 7.**

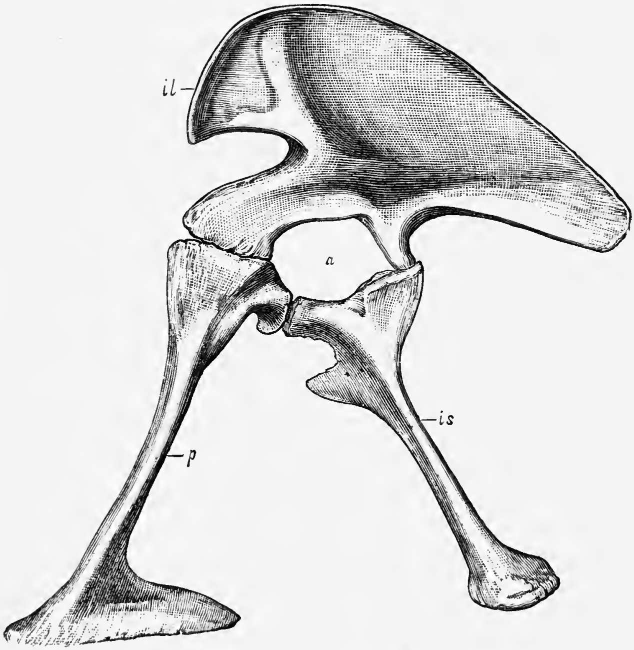


FIG. 15.—Left side of pelvis of *Allosaurus fragilis* (Marsh), from the Upper Jurassic of North America ($\frac{1}{12}$ nat. size). *a*, acetabulum; *il*, ilium; *p*, pubis; *is*, ischium (after Marsh).

Ornithopoda. All the forms were carnivorous. The premaxillary was furnished throughout with teeth, which are laterally compressed and backwardly curved, the cutting edges of one or both of which are frequently serrated. The teeth are planted in distinct sockets, and the skull has a large aperture in front of the eye, known as the preorbital vacuity. The centra of all the vertebræ are hollowed internally, and much compressed laterally.

Wall-case, No. 7. Table-case, No. 14.

The limb-bones always have medullary cavities, and the pectoral (fore-) limb being much shorter than the pelvic (hind-) limb, it is probable that many of the forms were bipedal in their

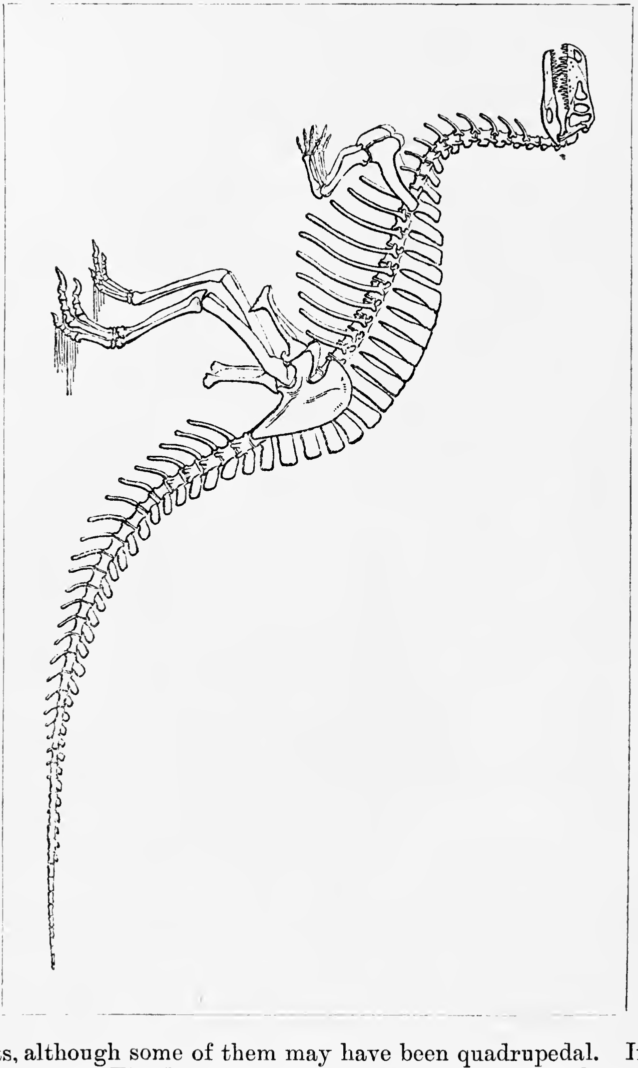


Fig. 16.—Restoration of the skeleton of *Megalosaurus Bucklandi* (Meyer), from the Great Oolite, Stonesfield (greatly reduced).

habits, although some of them may have been quadrupedal. In the pelvis (*see* Fig. 15) the ilium is of great vertical depth, and has a short preacetabular process, while the pubis is directed downwards and forwards, and unites with its fellow in a long bony symphysis, which generally extends up the anterior face of the two bones, giving them the shape of an elongated letter Y, when seen from the front. The pubis and ischium are comparatively short and slender. The *astragalus*, or "ankle-bone," usually fits closely to the tibia, and frequently gives off a long flattened process which is applied closely to the anterior face of the latter bone, resembling in this respect the free condition of these two bones in the young of Ratite birds before the anchylosis of the astragalus with the tibia has taken place.

The metatarsals are elongated and the feet digitigrade. In the manus (hand), the number of digits varies from four to five, while in the pes (foot), there may be either three or five. The terminal phalangeals in all cases have curved claws, which in the manus are very long and prehensile, evidently well adapted for seizing and holding living prey.

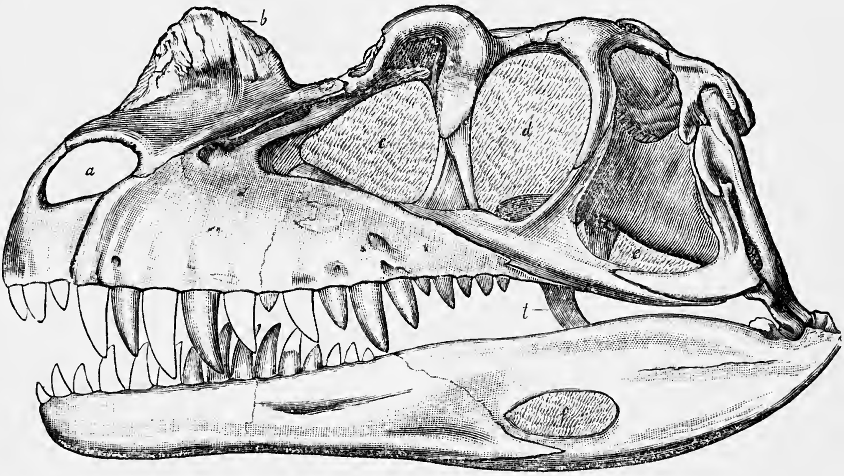


FIG. 17.—Left lateral view of skull of *Ceratosaurus nasicornis* (Marsh), from the Upper Jurassic, North America. *a*, nasal opening; *b*, horn-core; *c*, antorbital opening; *d*, orbit; *e*, lateral temporal fossa; *t*, transverse bone; *f*, mandibular vacuity ($\frac{1}{6}$ nat. size) after Marsh. (Not represented in the Collection.)

The skeleton of a small Dinosaur, of which a beautiful cast may be seen in Table-case No. 9, the original being preserved at Munich, named *Compsognathus longipes*, has been found entire in the Lithographic stone of Solenhofen. From the relative proportions of its limbs we cannot but conclude that it must have "hopped (like a Jerboa), or walked in an erect or semi-erect position, after the manner of a bird, to which its long neck, slight head, and small anterior limbs must have given it an extraordinary resemblance." (Huxley.) **Compsognathus. Table-case, No. 14.**

Teratosaurus. Megalosaurus. Table-case, No. 14.

Numerous other fine Dinosaurian remains are to be seen in the collection, but as we do not know the teeth of many of these huge reptiles, we cannot speak positively as to their habits. It is certain, however, that, from the Trias to the Chalk, two groups have existed, one having a carnivorous dentition, and the other being herbivorous. *Teratosaurus* of the Trias of Stuttgart, *Ceratosaurus* and *Allosaurus* of the American Jurassic rocks, *Megalosaurus* and *Compsognathus* of the Oolitic and Wealden strata were all carnivores.

Wall-case, No. 4.

The actual counterpart and casts of the maxilla and premaxilla and a portion of the ramus of the lower jaw of *Megalosaurus* from the Inferior Oolite, Sherborne, Dorset, may be seen in the Wall-case. Of *Polacanthus*, *Omosaurus*, and *Hylæosaurus*, we have no direct dental evidence, but judging from a comparison of the other portions of their skeletons, they have been referred to the family of the *Stegosauridæ*. No doubt, as amongst the Mammalia at the present day, the majority were vegetable-feeders, and the minority were predaceous in habit. The Cretaceous genus *Dryptosaurus*, and the Jurassic *Ceratosaurus* and *Allosaurus* were, in America, the representatives of the carnivorous *Megalosaurus* of our Secondary rocks.

Dryptosaurus. Megalosaurus.

Many species of *Dryptosaurus* have been identified, and a series of plaster-casts of bones of *Dryptosaurus aquilunguis* are exhibited in the case.

Wall-case, No. 7.

ANCHISAURIDÆ.—The genus *Anchisaurus* has amphicœlous cervical vertebræ, the pubis is rod-like, there are five digits in the manus and pes. The teeth are without serrations on the anterior border. *Epicampodon* (Fig. 18, A, B, C) is an allied genus from India.

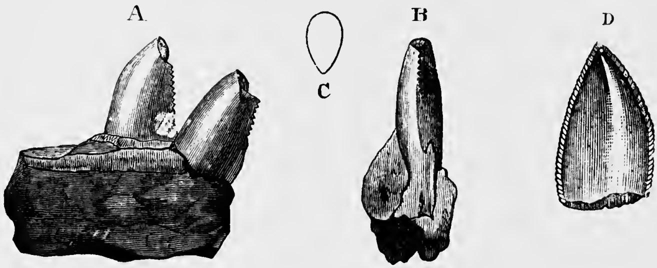


FIG. 18.—Fragment of mandible, *A*, lateral aspect; *B*, posterior aspect; *C*, section of tooth of *Epicampodon indicus* (Huxley), from the Panchet beds (U. Trias), Lower Gondwanas of Bengal; *D*, lateral aspect of tooth of *Thecodontosaurus platyodon* (Riley & Stutchbury), Upper Trias, Bristol.

In *Thecodontosaurus platyodon* (Fig. 18, D), the teeth have oblique serrations on both borders. The ilium is of the Megalosaurian type. Remains of this genus are met with in the Upper Trias, Durdham Down, Clifton, near Bristol, in Gloucestershire. **Wall-case, No. 7. Table-case, No. 14.**

SUB-ORDER 3.—Ornithopoda (Bird-footed).

This sub-order is taken to include the STEGOSAURIA of Marsh. **Wall-case, No. 4.**

The genus *Stegosaurus* was originally described by Marsh from the Upper Jurassic of North America, but certain forms from the Oxford and Kimmeridge Clay of England, described under the preoccupied name of *Omosaurus*, cannot be separated generically from *Stegosaurus*. They also agree with the *Scelidosauridæ* in the general structure of their teeth and in the possession of a dermal armour of scutes and spines, as well as

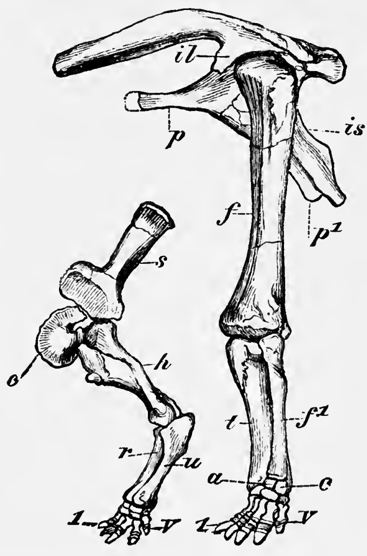


FIG. 19.—The left pectoral and pelvic girdles and limbs of *Stegosaurus ungulatus* (Marsh), from the Upper Jurassic of Southern Colorado, North America ($\frac{1}{32}$ nat. size), *s*, scapula; *c*, coracoid; *h*, humerus; *r*, radius; *u*, ulna; 1-*V*, phalangeals; *il*, ilium; *is*, ischium; *p*, *p* 1, pubis; *f*, femur; *t*, tibia; *f* 1, fibula; *a*, astragalus; *c*, calcaneum (after Marsh).

in their solid limb-bones. The neural arches of the vertebræ are very much higher, and in the sacrum each arch is chiefly or entirely supported by a single centrum, instead of by the adjacent portions of two centra as in the Ornithopoda.

The skull shows many points of resemblance to that of *Iguanodon*, especially by the presence of a predentary bone, but it is lower and narrower and in this respect it resembles the Scelidosaurian type.

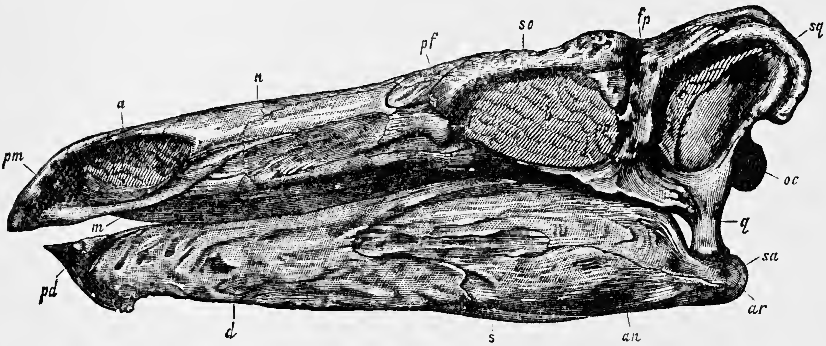


FIG. 20 —Left lateral view of skull of *Stegosaurus stenops* (Marsh), ¼ natural size; from the Upper Jurassic, S. Colorado, North America. *a*, nares; *b*, orbit; *c*, lateral temporal fossa; *pm*, premaxilla; *m*, maxilla; *n*, nasal; *pf*, prefrontal; *so*, supraorbital; *fp*, postfrontal; *po*, postorbital; *l*, lachrymal; *j*, jugal; *q*, quadrate; *sq*, squamosal; *oc*, occipital condyle; *ar*, articular; *sa*, surangular; *an*, angular; *s*, splenial; *d*, dentary; *pd*, predentary (after Marsh).

Wall-case, No. 4.

Omosaurus.

To this sub-order are referred the remains of a large Dinosaur from the Kimmeridge Clay of Swindon, Wilts, described by Sir Richard Owen in his Monograph on the Fossil Reptilia of the Mesozoic Formations (Palæontographical Society's Volume for 1875), under the name of *Omosaurus armatus*. The series comprises, in an immense block, the iliac bones of either side with the entire sacrum, retaining the normal form and position, an ischium, a femur, several dorsal and caudal vertebræ projecting in bold relief from the background of grey stone, forming a magnificent fossil group unique of its kind.

In addition to the bones above mentioned (which are all imbedded in one block 6′ 0″ × 7′ 6″), a large dermal spine, several centra and processes of many vertebræ and chevron-bones, an entire humerus, ulna and radius with carpal and metacarpal bones, all parts of the same fore-limb; also a complete ischium and pubis, and six caudal vertebræ, were found lying in the clay around the larger mass.

The femur measures more than 4 feet, and the humerus is nearly 3 ft. in length and enormously broad. The head and neck are unfortunately wanting, but there is little doubt that nearly the entire animal might have been obtained had some competent person been present in the pit when the remains were first observed.

Remains of another species of this genus (*Omosaurus durobrivensis*) from the Oxford Clay of Peterborough, are also exhibited in this case.

Fig. 21.— A single upper tooth of *Scelidosaurus Harrisoni* (Owen) twice nat. size, from the Lower Lias, Charmouth, Dorset.

Scelidosaurus, Case Y, on Plan.

A large plated Dinosaur has been discovered in a tolerably perfect state, and is placed in a glazed case in the centre of the Reptile gallery.

It was obtained from the Lower Lias of Lyme Regis, Dorset, and is a fairly complete skeleton of an herbivorous Dinosaur about 12 feet in length, closely allied by its dentition to *Iguanodon*, and described by Sir Richard Owen as *Scelidosaurus Harrisoni*. This reptile was armed with lateral rows of thick bony scutes or spines on each side, which extended along the tail also. There is very considerable disparity between the fore and hind-limbs, as in so many other Dinosaurs. There are four functional toes and one rudimentary one on the hind foot; the fore-foot is not well preserved and the number of digits cannot consequently be clearly made out in the hand.

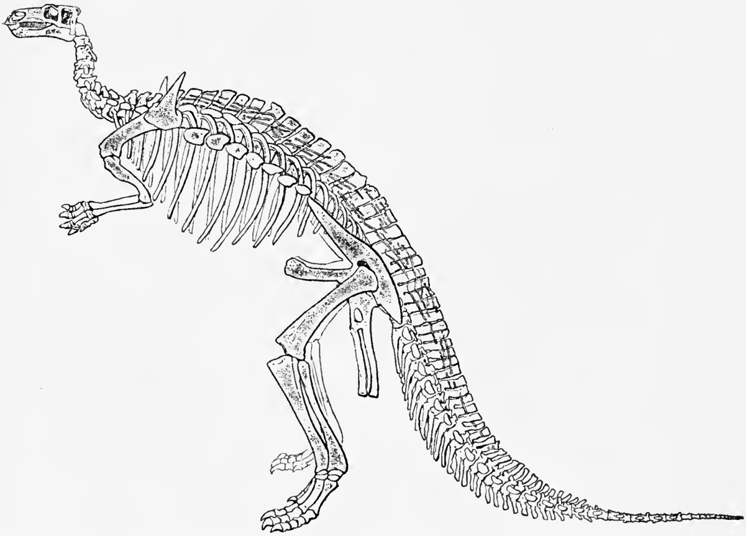


Fig. 22.—Restored skeleton of *Scelidosaurus Harrisoni* (Owen), greatly reduced, from the Lower Lias of Charmouth, Dorset. The figure shows the large lateral dermal spines on the shoulders, and the long lateral line of smaller spines, reaching from the pectoral region to the extremity of the tail; also the numerous ossified tendons running along the sides of the dorsal spines of the vertebræ from the shoulder to the tail. (The original specimen is about 12 feet in length.)

Acanthopholis. Table-case, No. 14.

A smaller Dinosaur, named *Acanthopholis*, found in the Lower Chalk of Dover, was also armed with spines, but only a few fragmentary remains of it are preserved in the collection.

Hylæosaurus.

The long dermal spines of *Hylæosaurus*, another armed Dinosaur from the Wealden, were arranged in a single row along the central line of the back.

Polacanthus. **Wall-case, No. 4.**

The *Polacanthus*, or many-spined Dinosaur, from the Wealden formation near Brixton, Isle of Wight, appears, as regards its dermal covering, to have been one of the most heavily armed of these old dragons. Its body was protected by a series of long, laterally-compressed, and more or less acutely triangular osseous spines, and also by numerous plain and keeled scutes; whilst the pelvic region was covered by a large shield or carapace of thick bone firmly united to the vertebræ and ribs, like the carapace in a turtle. The tail was also protected by strong bony dermal scutes.

Many of the limb-bones and vertebræ of the back and tail were found associated with the spines, but no remains of the neck or head.

The bases of the spines are broad and asymmetrical, showing that they were arranged in one or more rows on either side of the central line of the back. The largest of these spines exhibited measures ten inches in breadth, and in height thirteen inches.

Hypsilophodon. **Table-case, No. 16.** **Small Glass-case, y.**

We are mainly indebted to the researches of Prof. Huxley and Mr. J. W. Hulke for a knowledge of *Hypsilophodon Foxi*, a small Dinosaur from the Wealden, about 4 feet in length. The animal has four large and powerful digits to the hind foot, and a small rudimentary fifth outer toe; an extremely small fore foot (or *manus*), with four digits and a fifth rudimentary one. The sharp-pointed and curved ungual phalanges indicate that it was probably arboreal and rock-climbing in its habits. The sides of the crowns of the teeth are finely-serrated, and repeat in miniature the serrations of the crown of the teeth of *Iguanodon*. *Hypsilophodon* was destitute of any dermal armour. Remains of parts of several individuals have been met with at Brixton, in the Isle of Wight.

Iguanodon Mantelli. **Wall-case, No. 6, and Table-case, No. 15.**

"Mantell's Iguanodon."—This is one of the largest of the great extinct land-reptiles, some of which certainly rivalled the elephant in bulk. The femur (thigh bone) alone measured 4 to 5 feet in length. The fore-limbs were very short, so that it is almost certain that it did not make use of them constantly for progression on the ground, but could readily raise itself into an upright position, the weight of its body being counter-balanced by its long and ponderous tail, although it was far too bulky to progress by leaping, after the manner of a kangaroo. The slab in the centre of Case 6 contains a great portion of the skeleton of a young individual of *Iguanodon Mantelli* from Bensted's Kentish Rag quarry at Maidstone, in which the disproportion of the fore and hind limb is well shown. It will be seen that the bones of the arm and fore-arm (humerus, and radius and ulna) are barely half the length of the thigh and shin bone (femur and tibia). This difference between the leg and arm seems to have been a marked feature in a large

Wall-case, No. 6.

Table-case, No. 15.

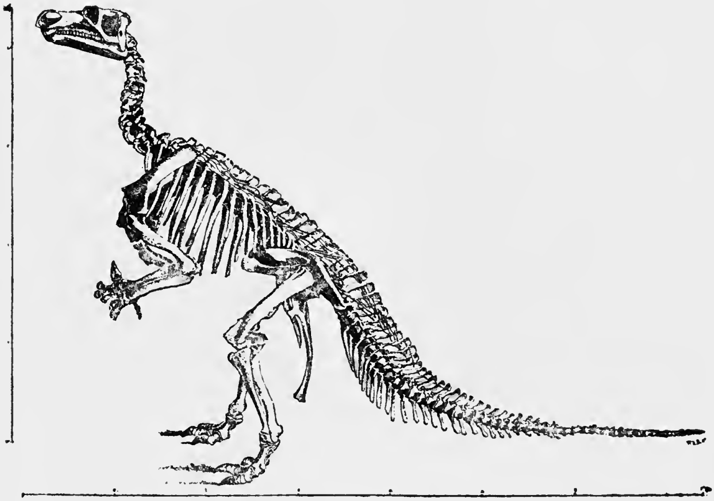


Fig. 23.—Restored skeleton, greatly reduced, of *Iguanodon Bernissartensis* (Boulenger); from the Wealden of Bernissart, Belgium (scale about $\frac{1}{75}$ nat. size). A reproduction of the original, which is preserved in the Royal Museum of Natural History, Brussels, is placed in the centre of the Reptile Gallery.

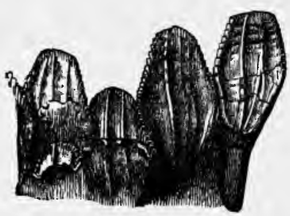


Fig. 24.—Outer view of four lower teeth of *Iguanodon* in fragment of jaw, showing unworn condition of teeth. From the Wealden of the Isle of Wight.

number of Dinosaurs, as may be well seen in *Hypsilophodon*, *Compsognathus*, and many others.

Of the larger species of Iguanodon, *I. Bernissartensis*, a reproduction of the entire skeleton is placed in the middle of the gallery, and a separate cast of the skull is also exhibited. The height of the skeleton as mounted is about 14 ft., and its length about 25 ft. The great difference in size between the fore and hind limbs noticed above is well shown. The original specimen is preserved in the Royal Museum of Natural History, Brussels, and is one of twenty-three more or less complete skeletons dis-

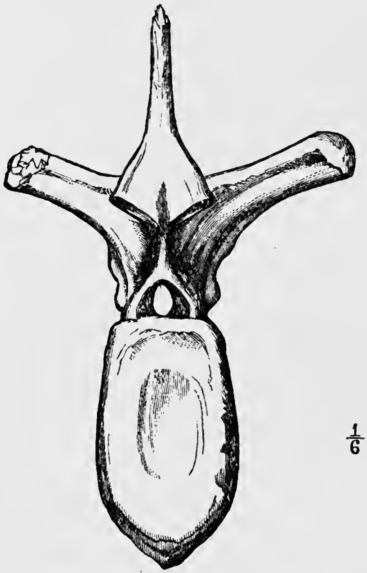


Fig. 25.—*Iguanodon Bernissartensis* (Boulenger). Posterior view of a dorsal vertebra; Wealden, Isle of Wight.

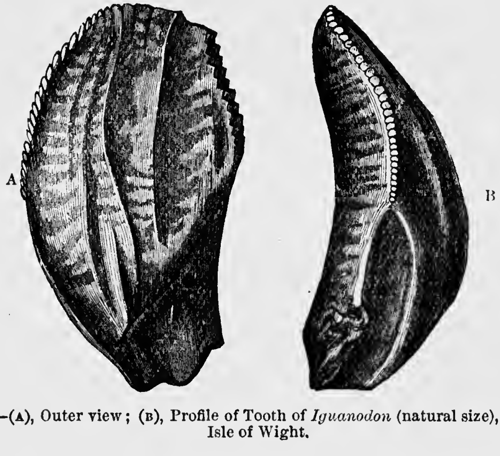


Fig. 26.—(a), Outer view; (b), Profile of Tooth of *Iguanodon* (natural size), Wealden, Isle of Wight.

covered at Bernissart in Belgium. Remains of this species from the Wealden of Sussex, and the Isle of Wight are exhibited in Wall-case 5.

Remains of other species are exhibited in Wall-case 4*a*.

Numerous foot-prints of these animals have been found in the Wealden deposits of Hastings, and are exhibited in Gallery No. 11, Wall-case No. 8.

In all cases only the impressions of the hind-foot are seen, so that there can be little doubt that the mounted skeleton correctly represents the position of the reptile when walking.

Iguanodon.

Wall-cases, Nos. 4a, 5, and 6.

Table-case, No. 15.

The *Iguanodon* was vegetarian in its diet, as is proved by its teeth, which correspond with those of the living and vegetable-feeding *Iguana* of S. America.

Their teeth are not unfrequently found worn down at the crown, like the molar teeth of the herbivorous mammalia at the present day. They were implanted in partially distinct sockets, and a succession of teeth always growing up from beneath replaced the worn-down stumps. The teeth are curved and leaf-shaped, and the edges are elegantly serrated, a character peculiar to all the vegetable-feeding Dinosaurs, such as *Acanthopholis*, *Scelidosaurus*, &c. (*see* Figs. 24 and 26).

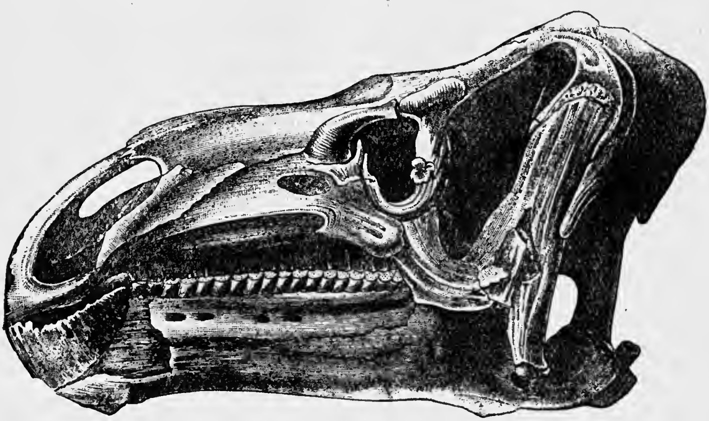


FIG. 27.—Left lateral aspect of skull of *Iguanodon Bernissartensis* (Boulenger); from the Wealden of Bernissart, Belgium (much reduced). The anterior aperture in the skull is the nares (nostril), the middle one the orbit, and the large posterior one, the lateral temporal fossa. The predentary bone is seen at the extremity of the mandible (after Dollo).

Table-case, No. 15.

The genus *Orthomerus* (Seeley), an Iguanodont, and a species of *Megalosaurus*, from the Upper Chalk of Maestricht, appear, so far as yet known, to be the most recent, and probably the last representatives in Europe in geological time of the great group of terrestrial Dinosaurs. Both species are founded upon a few long bones of limbs in the collection, and assuming them to have belonged to fully adult animals, their small proportions, when compared with those of their predecessors, probably indicates degeneration in an expiring race.

Table-case, No. 16.

In the genus *Trachodon*, of Leidy, all the dorsal vertebræ are opisthocœlous (hollow behind), with low arches, on which the rib-facet rises to the summit of the neural platform; the centra are moderately compressed and wedge-shaped, with a hæmal carina. The teeth are simpler than in *Iguanodon*, with lozenge-shaped crowns, the inferior surface of the root of each tooth being grooved for the reception of the summit of the tooth below. In *T. cantabrigiensis* the crowns of the teeth are relatively broader than in *T. Foulki*, from New Jersey (*see* Figures 28, A, B, C).

The following are of uncertain affinities, namely:—*Echinodon*, which was a large saurian probably of aquatic habits. The teeth were flat, broadly pointed, and the upper edges strongly serrated, hence the name "prickly-tooth." A more formidable saurian

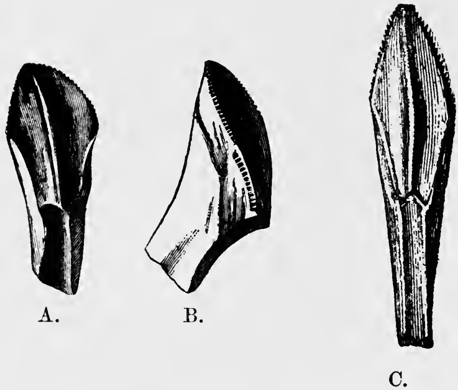


FIG. 28.—(A) lateral, and (B) profile views of a tooth of *Trachodon cantabrigiensis* (Lydekker), Greensand, Cambridge; (C), tooth of *Trachodon Foulki* (Leidy), Upper Cretaceous of New Jersey, U.S.A.

Nuthetes.

from the same deposit is the *Nuthetes destructor*. The teeth are flat, recurved, and finely serrated on their anterior and posterior margins, like miniature teeth of *Megalosaurus* which they resemble.

Order IV.—SQUAMATA (Scale-covered Reptiles).

This order is largely represented by forms living at the present day, as it includes the true Lizards, the Chamæleons, and the Serpents, and in the Cretaceous epoch by the great extinct Mosasaurians. In this order the body may be either short, with well developed limbs and a distinct tail, as in the Lizards; or it may be extremely elongated without any external trace of limbs, and passing gradually into the tail, as in the Snakes. As a rule, the whole body and limbs are covered with overlapping horny scales, and these may be underlain by an armour of bony dermal scutes. The limbs may be adapted for walking on land, or modified into paddles for swimming. In the skull the proximal end of the quadrate bone is more or less movably articulated; the lower temporal arcade is wanting; the post-orbital is generally fused with the post-frontal; the palate is more or less open, the pterygoids being nearly always separated by an interval from one another, and the premaxillæ are frequently united. The vertebræ are generally procœlous (concave in front), although more rarely they are amphicœlous (bi-concave). True abdominal ribs are never developed. The carpus has but a single centrale, and the precoracoid process is often well marked.

SUB-ORDER 1.—Ophidia (Serpents).

Serpents. Table-case, No. 3.

Palæophis.

Serpents are rarely met with in a fossil state, but a few such remains have been obtained from the Tertiary rocks. The earliest Ophidian represented in the Collection is the *Palæophis*

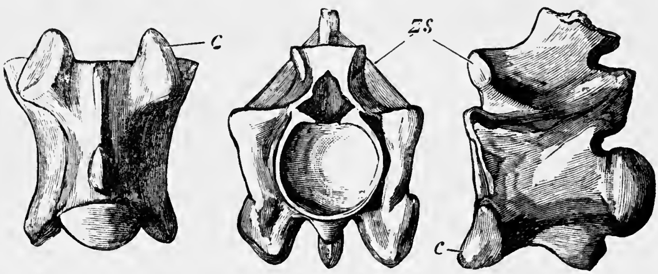


FIG. 29.—Vertebræ of *Palæophis typhæus* (Owen), from the Lower Eocene, Sheppey. A, hæmal; B, anterior; and C, left lateral views of a trunk vertebra, wanting most of the neural spine; *zs*, zygosphene; *c*, costal articulation.

toliapicus, a serpent about 12 feet in length, obtained from the London Clay of Sheppey; from the Middle Eocene of Bracklesham we have a still larger form, the *Palæophis typhæus*, a boa-constrictor-like snake, considered to be marine, that attained a length of 20 feet, and also a smaller species, *P. porcatus*.

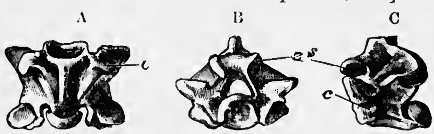


FIG. 30.—(A) Hæmal, (B) Anterior, (C) left lateral views of a trunk-vertebra of *Paleryx rhombifer* (Owen), from the Eocene Phosphorites of Caylux, France. *c*, costal articulation; *zs*, zygosphene.

Paleryx.

The Upper Eocene sands of Hordwell have yielded numerous vertebræ of snakes, but of a much smaller size, namely, *Paleryx* *rhombifer* and *P. depressus.* Others are recorded from the Miocene of Œningen and the Lignites of Bonn-on-the-Rhine, and are exhibited in this case.

SUB-ORDER 2.—Lacertilia (Lizards).

Lizards. Table-case, No. 3.

The earliest known member of the large group of existing Lacertian reptiles is *Macellodus* (with which *Saurillus* is probably identical, or closely allied), mostly known by jaws and teeth from the Purbeck beds of Swanage, Dorset, a small lizard with pleurodont dentition, dermal scutes, and procœlous vertebræ.

Coniasaurus, with expanded teeth, occurs in the Chalk of Kent and Sussex. Several genera of lizards are represented in the Tertiaries of France and America. Remains of a species of *Iguana* occur in the Eocene Phosphorites of France, and the Middle Eocene of Hordwell, Hampshire.

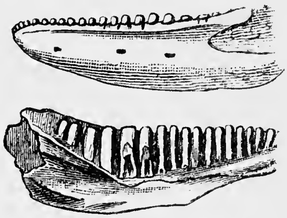


FIG. 31.—(A) Outer, and (B), inner views of the left dentary bone of an Anguoid Lizard; from the Eocene Phosphorites of Caylux, France. $\frac{1}{1}$.

The *Anguidæ* (Slow-worms) are represented by several genera from Gers in France (Middle Miocene), and from Rott, near Bonn (Lower Miocene); from Steinheim, Bavaria; and from England and North America.

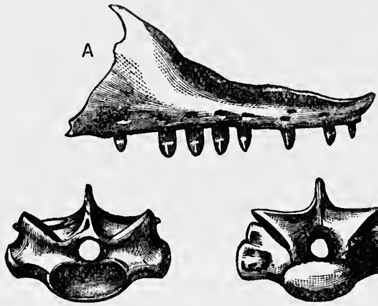


FIG. 32.—(A) Right Maxilla; (B) Anterior, and (C) Posterior views of a dorsal vertebra of *Varanus bengalensis* (Daudin), Pleistocene, Madras. $\frac{1}{1}$.

The *Varanidæ* (Monitors) are represented by a very large form *Megalania*, from Queensland, Australia, and by *Varanus* *sivalensis* from the Siwalik Hills of India. Fragments of jaws, vertebræ, etc., referred to *Varanus bengalensis*, from caves, Karnul, Madras, are preserved in the collection. Similar specimens have been described by Mr. Lydekker (*see* Palæontologia Indica).

From the Chalk of Sussex and Kent have been obtained several examples of the snake-like lizard *Dolichosaurus longicollis*, and an allied genus *Aigialosaurus* is represented in the collection by a fine specimen of a nearly complete skeleton from the Cretaceous of the Island of Lesina, Dalmatia.

Dolichosaurus.

Sub-order 3.—**Pythonomorpha.**

The *Mosasauridæ* were carnivorous marine reptiles, frequently of great size, and ranging in time from the Upper Greensand to the uppermost Cretaceous beds, and having a

Wall-case, No. 7.

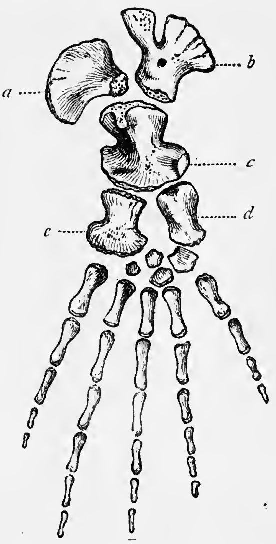


Fig. 33.—Right pectoral limb of a Mosasauroid reptile, *Platecarpus*, sp. Cretaceous strata of North America. $\frac{1}{12}$ nat. size (after Marsh.) *a*, scapula; *b*, coracoid; *c*, humerus; *d*, radius; and *e*, ulna.

world-wide distribution. The body was much elongated; the skull offers a strong resemblance to the *Varanidæ* amongst the lizards, and has the nasal and premaxillæ welded together; the quadrates very loosely articulated; teeth on the pterygoids as well as in the jaws, and frequently ossifications in the sclerotic of the eye. The teeth are large and sharp, and anchylosed by expanded bases to the summits of the jaws. The clavicles are always, and the interclavicles and sacrum generally, wanting.

Wall-case, No. 7.

The limbs are modified into paddles with no claws to the terminal phalangeals and no foramen to the humerus. The majority of forms were devoid of dermal scutes.

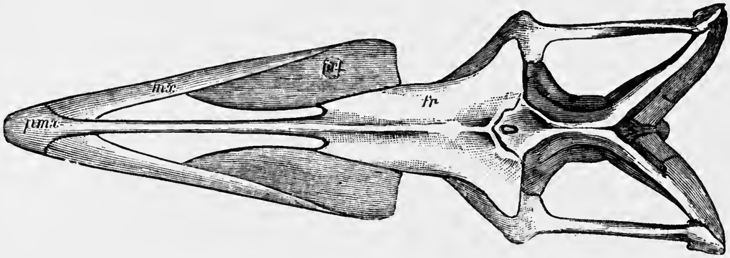


Fig. 34.—Superior aspect of the cranium of *Platecarpus curtirostris* (Cope); from the Upper Cretaceous of N. America (greatly reduced). *pmx*, premaxilla; *mx*, maxilla; *fr*, frontal; *prf*, prefrontal (after Cope).

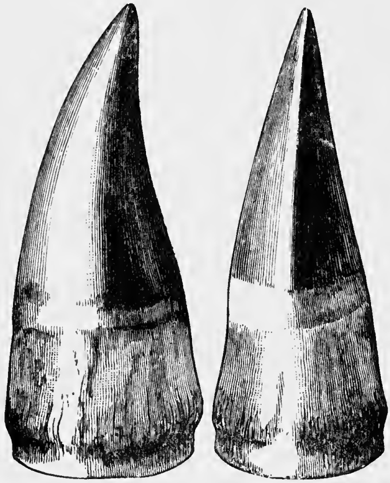


Fig. 35.—Lateral and profile views of a lower tooth of *Liodon*, sp. from the Upper Cretaceous of Maestricht, Holland, 1/1.

Mosasaurus.

These great aquatic lizard-like reptiles, known as the *Mosasaurus*, *Liodon*, etc., once inhabited the shores of the sea in which the uppermost Chalk, or Maestricht beds, were deposited, and their powerful jaws, armed with great grooved, recurved, conical teeth, their vertebræ and various other skeletal remains have been obtained from St. Peter's Mount, near Maestricht, Holland, and from the Chalk of Norfolk and Kent. Remains of over forty species have been found in the Cretaceous rocks of New Jersey, Kansas, &c., in North America. One of these, the *Mosasaurus princeps*, is computed to have been 75 to 80 feet long. The paddles, which were four in number, each with five digits, had a remarkable resemblance to the "flippers" of a whale (*see* Fig. 33). **Wall-case, No. 7.**

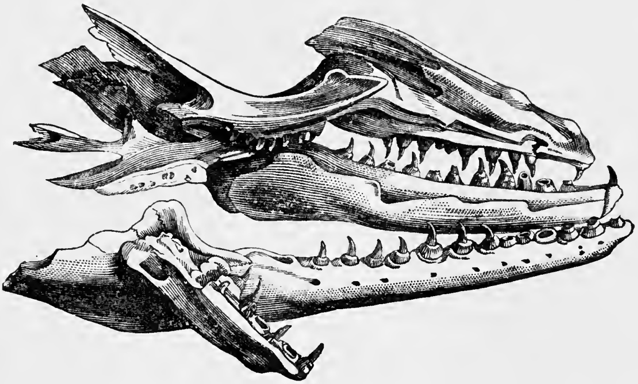


FIG. 36.—The imperfect skull of *Mosasaurus Camperi* (Meyer), from the Upper Cretaceous of Maestricht, Holland (much reduced).

Order V.—RHYNCHOCEPHALIA (Beak-headed Lizards).

Wall-case, No. 8.

This order has only one living representative, the genus *Sphenodon* (*Hatteria*), from New Zealand. Its earliest known ancestor, *Palæohatteria*, dates from the Permian. In external appearance the Rhynchocephalians were lizard-like animals. They have the quadrate bone of the skull immovably fixed by the proximal extremity to the pterygoid, the palate is closed anteriorly by the median union of the pterygoids which extend to the vomers; the premaxillæ are never united. The teeth are acrodont, being anchylosed to the jaws. Abdominal ribs are always present.

Rhynchosaurus.

Wall-case, No. 8.

Under the name of *Rhynchosaurus articeps*, Sir Richard Owen described and figured, in 1842, a very interesting reptile from the fine-grained white Triassic sandstone of the Grinsill quarries near Shrewsbury (Trans. Cambridge Phil. Soc., vol. vii., part iii., p. 355, pl. 5 and 6). The vertebræ are biconcave, but whilst in some characters of the processes they resemble recent lizards, in others they present characters like those of the Dinosauria. The skull presents the form of a four-sided pyramid compressed laterally; it is also remarkable for the beak-like prolongation of the premaxillaries, which are pointed and recurved, and may have been encased in a horny sheath, like the mandible of a bird of prey. It had also, like the still existing New Zealand lizard *Sphenodon* (*Hatteria*), to which it is closely allied, two rows of minute acrodont teeth, united to a sharp edge of the maxillary and palatine bones respectively, between which the teeth of the lower jaw fit in a longitudinal groove.

Wall-case, No. 8.

This character was unknown until a few years ago, when a skull in the collection, having the mandibles in natural position, was skilfully developed from the matrix, and revealed the fact. The biconcave form of the vertebræ, sternal and abdominal ribs, and general characters of the limbs, also show the near affinity of this ancient extinct land-lizard to its living representative.

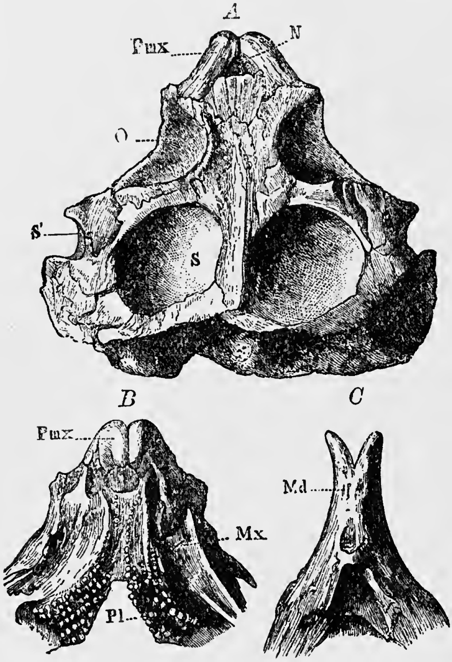


Fig. 37.—Skull of *Hyperodapedon Gordoni* (Huxley), Triassic Sandstone, Lossiemouth, Elgin, Morayshire, Scotland ($\frac{1}{4}$ nat. size). A, upper surface of skull; B, palatal aspect of skull; C, under side of front of lower jaw; *Pmx*, premaxillary bone; *Mx*, maxillary; *Pl*, palatal teeth; *Md*, mandibles; *O*, orbit. *N*, anterior nares: *S*, supratemporal fossa; *S'*, lateral temporal fossa.

Hyperodapedon.

Wall-case, No. 8.

Another form, but of much larger proportions, named by Prof. Huxley, *Hyperodapedon*, has been obtained from the Triassic sandstone of Elgin, Morayshire, Scotland, having the same compressed broadly triangular form of skull, with the orbits directed upwards and the premaxillaries prolonged into a sharp recurved beak, like *Rhynchosaurus*, which also may have been encased in a horny sheath.

The dentition is very peculiar, the maxillary and palatine bones being provided with several rows of well-developed low conical teeth closely set, and so arranged posteriorly as to form a deep longitudinal groove between two or more rows of teeth on each side for the reception of the marginal teeth of the mandible; these teeth are small and closely arranged, and wear by attrition with the upper teeth into a sharp cutting edge. There is also present on the inner side of the mandible a series of large and obtuse teeth. **Wall-case, No. 8.**

The fine specimen of *Hyperodapedon Gordoni* exhibited from Elgin shows the head, neck, and body region, and some of the limb-bones in fair preservation, but the whole of the caudal region is absent. It was a terrestrial reptile, and attained a length of six or seven feet, and does not appear to have been armed with scutes or spines, but there are traces of wrinkled (skin) markings on the slab near the vertebræ.

A much larger species, named *Hyperodapedon Huxleyi*, has been obtained from the Triassic deposits of Maleri, India, of which a good series of the jaws is exhibited. It is computed to have attained a length of 17 ft.

Prof. Huxley remarks ("Quart. Journ. Geol. Soc.," vol. xliii., 1887) that this order had already attained its greatest degree of specialization as early as the Trias; *Hyperodapedon* being in all respects a more modified form than *Sphenodon*. It appears therefore to be probable that in the Permian, or perhaps still earlier, there must have existed Lizards differing less from the existing genus than either *Hyperodapedon* or *Rhynchosaurus*.

Aphelosaurus, from the Permian, France, is also placed here.

From the Trias of Elgin in Scotland, we have the very small Lacertian, the *Leptopleuron (Telerpeton)*, not exceeding seven inches in length.

The *Saurosternon* is another small form of Triassic lizard, from the reptiliferous sandstones of South Africa.

The *Pleurosauridæ* are typically represented by *Pleurosaurus*, of the Lithographic stone of Bavaria, which is a medium-sized Lizard characterized by the extreme elongation of the body (in which there are a great number of presacral vertebræ), and the skull is long and narrow, with slit-like nares. *Anguisaurus* and *Acrosaurus*, of the same deposits, belong to this family, but it is not certain that they are really distinct from the type genus. **Wall-case, No. 8.**

From the same horizon also we have *Sapheosaurus*, *Ardeosaurus* and *Homœosaurus*.

Order VI.—PROTEROSAURIA.

To this order is referred a reptile named *Proterosaurus Speneri*, from the Permian "Copper-slates" of Thuringia. Though capable of progression on land, it was evidently of aquatic habits, feeding upon the *Palæoniscidæ* and other fishes, which abounded in the seas of that period. **Proterosaurus. Wall-case, No. 8.**

Wall-case, No. 14, Table-cases, Nos. 4 and 5.

Order VII.—ICHTHYOSAURIA (Fish-Lizards).

These great marine carnivorous reptiles had very short necks (*see* Woodcut, Fig. 43), probably not visible at all ex-

Fig. 38.—Left lateral aspect of the skull of *Ichthyosaurus communis* (Conybeare); from the Lower Lias, Lyme Regis, Dorset (about $\frac{1}{5}$ nat. size). The body was entirely devoid of any hard exo-skeleton.

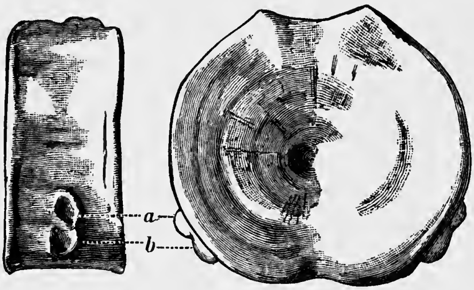


Fig. 39.—Left lateral and anterior aspects of the centrum of an early posterior dorsal vertebra of *Ichthyosaurus trigonus* (Owen); Kimmeridge Clay, Stanton. *a*, upper, *b*, lower costal tubercle.

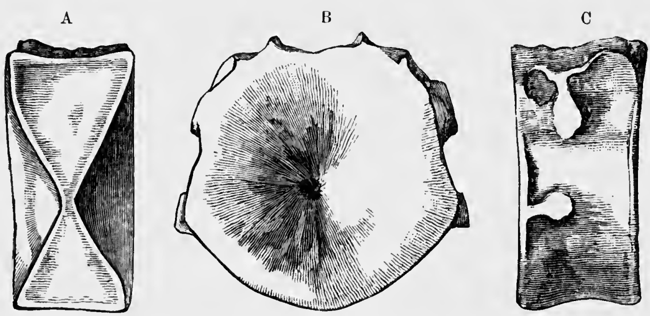


Fig. 40.—The centrum of an anterior dorsal vertebra of *Ichthyosaurus entheciodon* (Hulke); Kimmeridge Clay, Wilts. A, section: B, anterior aspect; C, left lateral aspect.

ternally. The vertebræ are numerous and deeply biconcave (*see* Fig. 40, A). They are primarily divisible into a precaudal

Wall-case, No. 14. Table-cases Nos. 4, 5.

and a caudal series without any differentiated sacrum, the precaudals have an upper and a lower costal or rib-tubercle on the centrum; the caudals have a single tubercle; the neural arches are attached by synchondrosis (by cartilage or gristle) to the flat surfaces on the centra. Intercentra are present between the skull and atlas, the atlas and axis, and the axis and the third vertebræ. The precaudal ribs are double-headed. Ribs are present in the caudal region; the chevrons are not united below. Abdominal ribs are present, but there is no sternum. There are clavicles and a T-shaped interclavicle present in the pectoral girdle; the coracoids do not overlap, there is no ossified pre-

FIG. 41.—Left lateral aspect of skull of *Ichthyosaurus latifrons* (König), from the Lower Lias of Barrow-on-Soar, Leicestershire, $\frac{1}{8}$ nat. size.

coracoid. The pelvis is weak, the iliac bones are not connected with the vertebræ, and there is an open obturator notch. The skull has very large orbits, and the eyes were surrounded by a ring of broad bony (sclerotic) plates. The jaws are elongated, and armed with powerful teeth implanted in grooves. The hand and foot are modified into fin-like organs, composed of short polygonal

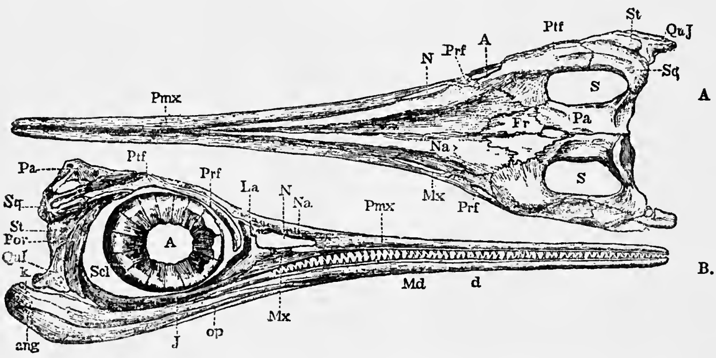


FIG. 42.—A, superior, and B, right lateral aspect of the skull of *Ichthyosaurus zetlandicus* (Seeley) from the Upper Lias of Normandy (reduced). *Pmx*, premaxilla; *Mx*, maxilla; *N*, nares; *Na*, nasal; *Fr*, frontal; *Prf*, prefrontal; *Ptf*, postfrontal; *Pa*, parietal; *J*, jugal; *QuJ* quadratojugal; *Sq*, squamosal; *St*, supratemporal; *Por*, postorbital; *A*, orbit; *S*, supratemporal fossa; *Scl*, sclerotic; *Md*, mandible; *d*, dentary; *op*, splenial; *ang*, angular; *k*, articular (after Zittel), $\frac{1}{4}$ nat. size.

bones, arranged in five closely approximated rows, with supernumerary rows of marginal ossicles added (*see* Figs. 45 and 46).

The largest entire *Ichthyosaurus* is from Lyme Regis, and measures 22 feet in length and 8 feet across the expanded paddles; but detached heads and parts of skeletons prove that they often attained a far larger size than this.

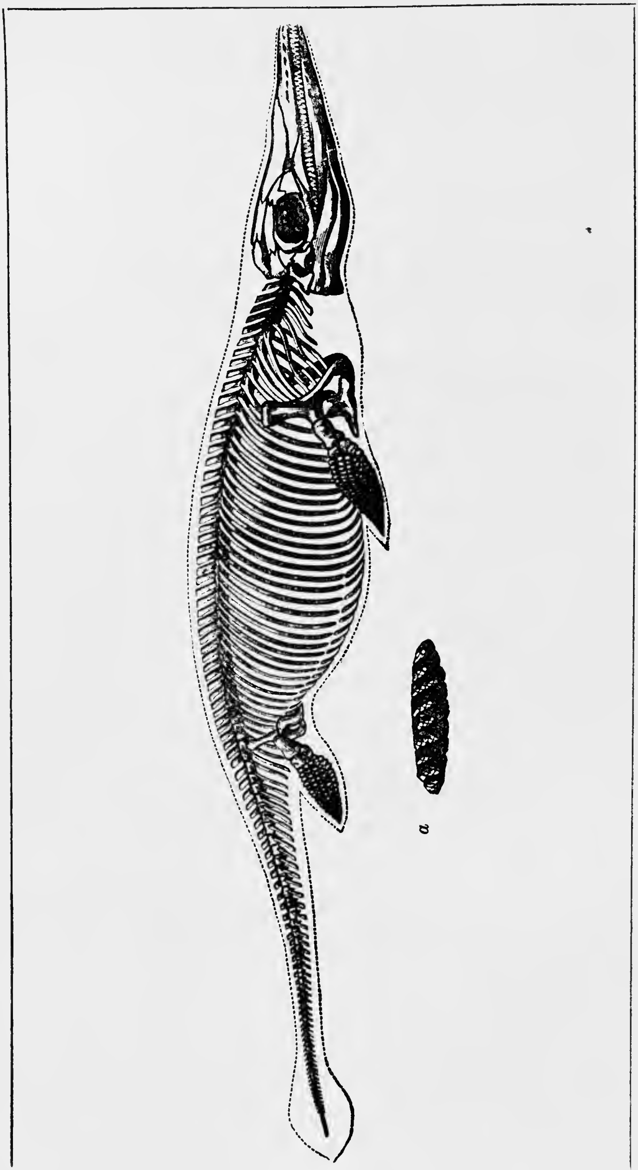


Fig. 43.—Skeleton of the Short-necked Marine Fish-Lizard (*Ichthyosaurus*), from the Lias of Lyme Regis, Dorset. *a* represents one of the coprolites of these saurians.

Gallery, No. 11. Wall-case, No. 13.

In some of the Ichthyosaurs the jaws are prolonged into a long and slender rostrum; others have short and robust heads, and jaws armed with large teeth. A most perfect example of the long and slender-jawed form of *Ichthyosaurus tenuirostris*, from the Lower Lias of Street, Somerset, was presented in 1884, by Alfred Gillett, Esq., of Street, Somerset.

Wall-case, No. 14.

Of *Ophthalmosaurus icenicus* a fine shoulder-girdle and paddle obtained by Mr. Leeds from the Oxford clay near Peterborough are mounted in Wall-case 14. In this genus and in *Baptanodon* from N. America three bones articulate with the distal end of the humerus, and some diversity of opinion exists as to their homology. Marsh and Hulke correlate them as in *Ichthyosaurus*, with the radius, intermedium, and ulna; Seeley terms them radius, ulna, and olecranon; whilst Baur considers that they represent the radius, ulna, and pisiform.

A B C

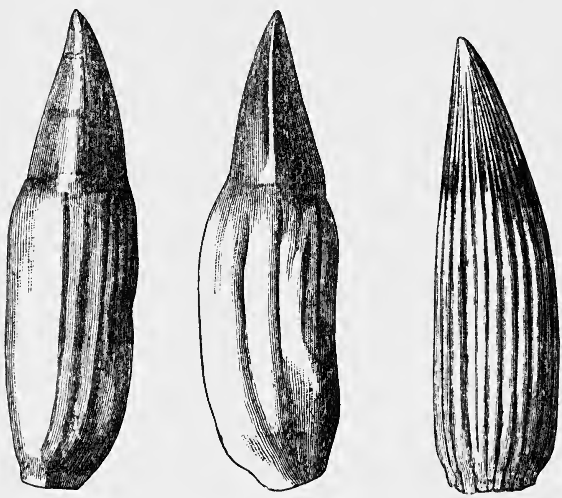


Fig. 44.—(A) Lateral and (B) profile views of a tooth of *Ichthyosaurus platyodon* (Conybeare); Lower Lias, Lyme Regis, Dorsetshire. (C) Tooth of *Ichthyosaurus communis* (Conybeare); Lower Lias, Lyme Regis, Dorset.

It has been shown by Baur that the Ichthyopterygia have almost certainly taken their origin from terrestrial or amphibious ancestors. The structure of the limb in the more generalized species of *Ichthyosaurus* indicates that the pectoral limb consists primarily of only four digits, the first digit being unrepresented, and the fourth and fifth arising in the usual manner from the ulnare. The additional rows of phalangeals in the more specialized forms it is suggested are due to a splitting up of the radial (2nd) and intermedial (3rd) digits, the presence of

Wall-case, No. 14.

Table-cases, Nos. 4, 5.

two centralia in the carpus of these higher forms is therefore an acquired and not an inherited character.

The structure of the palate is essentially the same as in *Sphenodon*. There is a remarkable resemblance between the Ichthyopterygia and the Rhynchocephalia in the structure of the pectoral arch, in the presence in both of abdominal ribs; in the similar position of the parietal foramen in the cranium, and the relation of the quadratojugal to the surrounding bones. In both there is the same absence of a lateral vacuity in the mandible.

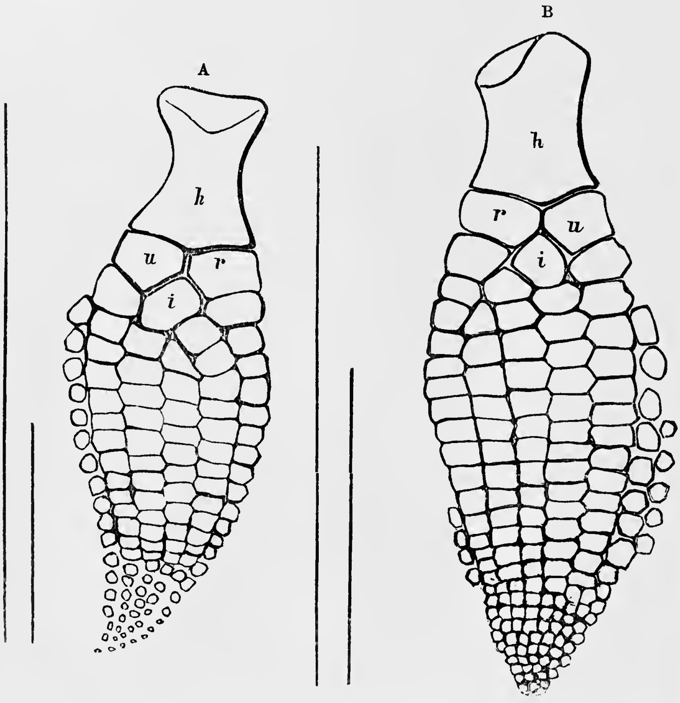


FIG. 45.—(A) Ventral aspect of the left pectoral limb of *Ichthyosaurus Conybeari* (Lydekker); Lower Lias, Lyme Regis (½ nat. size). *h*, humerus; *r*, radius; *u*, ulna; *i*, intermedium. The vertical lines show the relative lengths of the limb and the skull, the longer line being that of the skull. The notches in the anterior border of the first row of phalangeals are omitted. (B) Dorsal aspect of the left pectoral limb of *Ichthyosaurus communis* (Conybeare); Lower Lias, Lyme Regis. The letters and lines are the same as in Fig. A.

The teeth are confined to the jaws and are implanted in a continuous groove, without anchylosis of the bone. Their crowns are sharply pointed, and they are usually cylindrical and deeply fluted, more rarely carinated, compressed, or smooth (*see* Fig. 44 A, B, C).

Wall-cases, No. 14. Table-cases, Nos. 4, 5.

The humerus and femur are relatively short, but the radius and tibia are still shorter, and may be reduced to oblong bones in which the breadth is greater than the length. The humerus has no foramen. Usually the anterior pair of (pectoral) paddles is the larger (*see* Figs. 45 A, B; and 46 A, B). The humerus and femur in this order are unique in that, instead of having convex condyles for the articulation of the fore-arm (radius and ulna) they present distinct concavities for their reception.

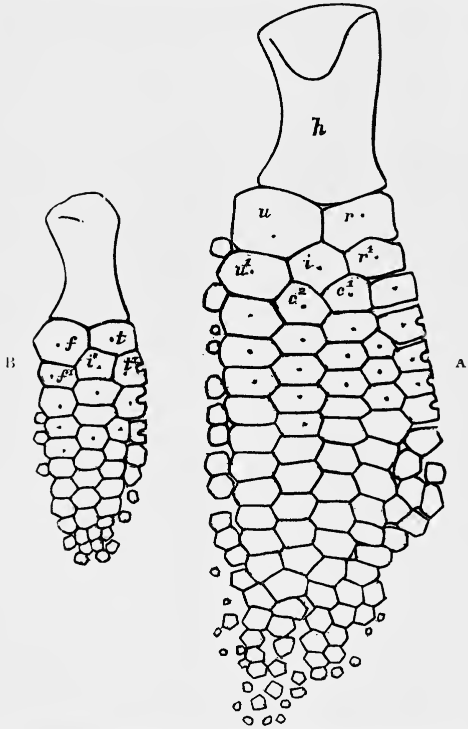


FIG. 46.—(A) Dorsal aspect of the left pectoral, and (B) ventral aspect of the right pelvic limb of *Ichthyosaurus intermedius* (Conybeare); Lower Lias, Lyme Regis, Dorsetshire. A. *h*, humerus; *r*, radius; *u*, ulna; *r* 1, radiale; *i*, intermedium; *u* 1, ulnare; *c* 1, *c* 2, centralia; B. *f*, femur; *.t*, tibia; *.f*, fibula; *t* 1, tibiale; *f* 1, fibulare; *i*, intermedium.

These old marine lizards must have exercised the same repressive action over the teeming animal population of the old Liassic seas that the sharks do in our seas at the present day. They existed during the long period of geological time represented by the several formations extending from the Upper Trias and Rhætic to the Chalk inclusive (*see* Table of Stratified Rocks, p. x.), but they occur in the greatest abundance, both as

See also Gallery XI, Wall-cases, Nos. 12 and 13.

regards individuals and species, and also in the most perfect preservation, in the Lias formation. Geographically, they enjoyed an exceedingly wide range of distribution, their remains having been discovered in the Arctic regions, in Europe, India, Ceram, North America, the East Coast of Africa, Australia, and New Zealand. Nearly entire skeletons of both young and adult animals have been obtained from beds of Liassic age with but few of the bones displaced, as may be seen by many specimens in the Wall-case.

Narrow Gallery V.

Tortoises and Turtles

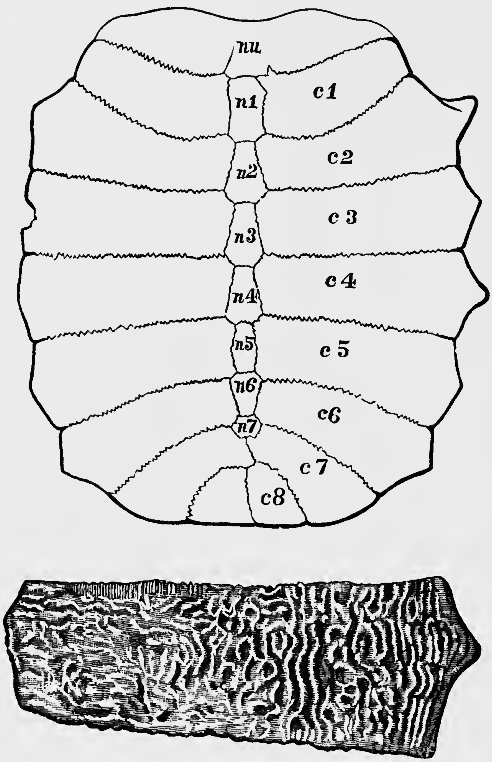
Wall-cases, Nos. 11 and 12.

Table-cases, Nos. 19, 20, 21.

Order VIII.—CHELONIA (Tortoises and Turtles).

The Chelonia are exhibited in two wall-cases and three table-cases placed in the West Corridor (No. 5 on Plan), which connects the Mammalian with the Reptilian Galleries.

A.



B.

Fig. 47.—A. Carapace of *Trionyx Gergensi* (Meyer), from the Lower Miocene of the Mayence Basin, ¼ nat. size; *nu*, nuchal; *c*1 to *c*8, costals; *n*1 to *n*7, neurals. B. The fourth right costal plate with the sculpture drawn on a larger scale.

Here are placed the fossil remains of the order CHELONIA, most largely represented at the present day, including the Tortoises and Turtles, a group of reptiles in which the vertebræ and ribs are immovable, being combined with the external coat of bony plates, closely connected by interlocking sutures,

Wall-cases, Nos. 11 & 12, and Table-cases, Nos. 19, 20, 21

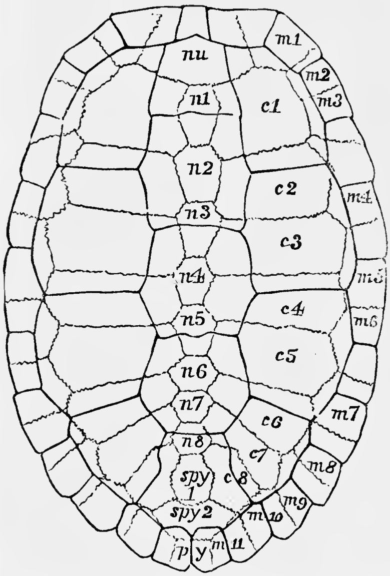


FIG. 48. — Outline of the Carapace, or dorsal shield, of *Hardella Thurgi* (Gray), reduced. *nu*, nuchal; *n*1–*n*8, neurals; *c*1–*c*8, costals; *spy*, 1 & 2, suprapygals; *py*, pygals; *m*1–*m*11, marginals. In both these figures the outlines of the bones have wavy sutures, the firm dark lines show the outlines of the overlying horny shields.

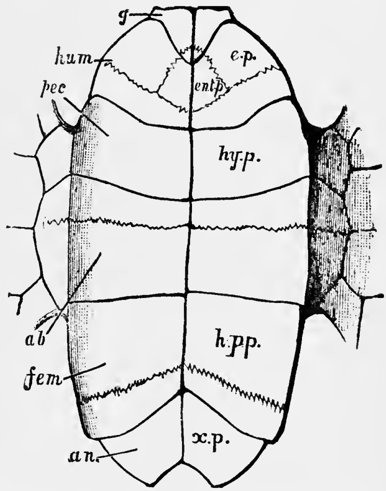


FIG. 49. — The plastron, or ventral shield, of *Cachuga tectum* (Gray), reduced; *ep.*, epiplastral bone; *entp.*, entoplastral bone; *hy.p.*, hyoplastral bone; *xp.*, xiphiplastral bone; *g*, gular shield; *hum.*, humeral; *pec.*, pectoral; *ab.*, abdominal; *fem.*, femoral; and *an.*, anal shields.

The originals of Figs. 48 and 49 are both from the Pliocene, Siwalik Hills, India.

enclosing the entire body of the animal. This box-like envelope is covered with leathery skin or horny shields; one kind of which is called "tortoise-shell," and is made into combs, &c. There are no teeth, the jaws being encased in a horny beak, the sharp edges of which serve instead for dividing the food.

The Chelonians are found living at the present day on land, in fresh water, and in the sea; they are all oviparous, depositing their eggs in the sand, to be hatched by the warmth of the sun. Some recent Turtles' eggs from Ascension, cemented together and fossilized in shell-sand by deposition of lime (produced through the rapid evaporation of the sea-water by the sun's heat), are exhibited in Wall-case, No. 12.

Wall-case No. 12.

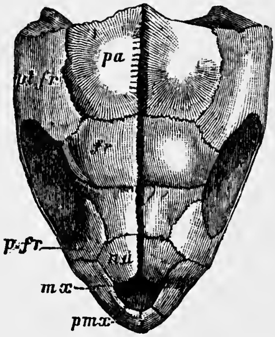


Fig. 50.—Frontal aspect of the cranium of *Rhinochelys cantabrigiensis* (Lydekker); from the Greensand, Cambridge. $\frac{1}{1}$. *pmx*, premaxilla; *mx*, maxilla; *na*, nasal; *p.fr*, prefrontal; *fr*, frontal; *pt. fr*, postfrontal; *pa*, parietal (the cranium is imperfect posteriorly).

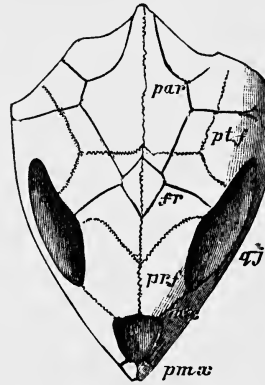


Fig. 51.—Frontal aspect of the cranium of *Argillochelys antiqua* (König); from the London Clay of Sheppey, $\frac{1}{1}$. *pmx*, premaxilla; *mx*, maxilla; *qj*, quadratojugal; *prf*, prefrontal; *fr*, frontal; *ptf*, postfrontal; *par*, parietal.

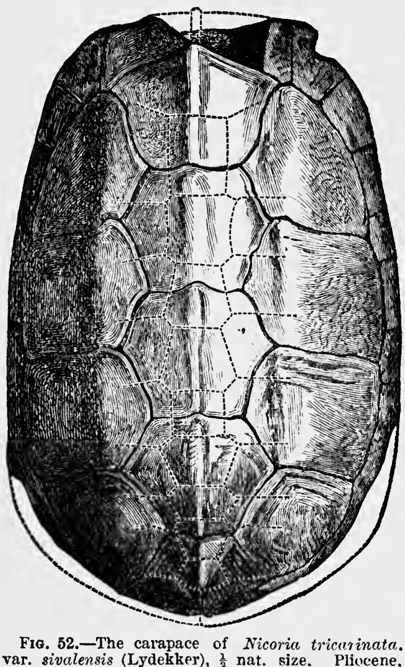


Fig. 52.—The carapace of *Nicoria tricarinata*. var. *sivalensis* (Lydekker), $\frac{1}{2}$ nat. size. Pliocene, Siwalik Hills, India. (The dotted lines indicate the bony sutures, the dark lines the horny shields.)

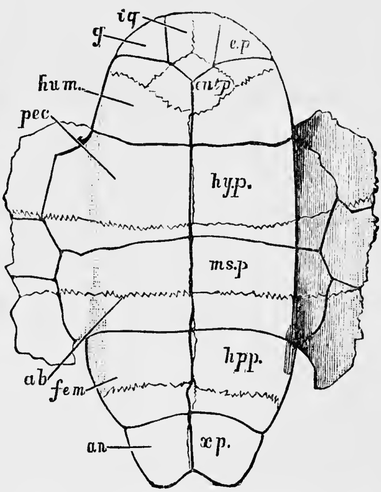


Fig. 53.—The plastron, or ventral shield, of *Pleurosternum Bullocki* (Owen), from the Purbeck beds of Swanage, Dorset. About $\frac{1}{5}$ nat. size; *ig.*, intergular shield; *ms.p.*, mesoplastron; the rest of the letters and explanation as in Fig. 49.

Tertiary and Secondary Chelonia.

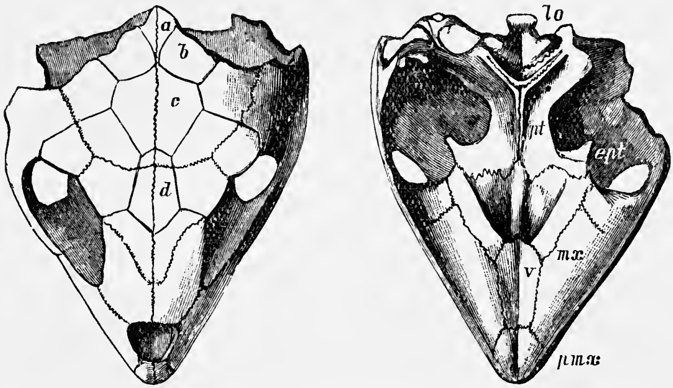


FIG. 54.—A, Frontal, and B, Palatal aspects of the cranium of a young individual of *Argillochelys cuneiceps* (Owen), from the London Clay of Sheppey. *pmx*, premaxilla; *mx*, maxilla; *pt*, pterygoid; *ept*, ectopterygoid process of the pterygoid; *bo*, basioccipital; *a*, occipital shield; *b*, paraoccipital shield; *c*, interparietal shield; *d*, frontal shield. ½ nat. size.

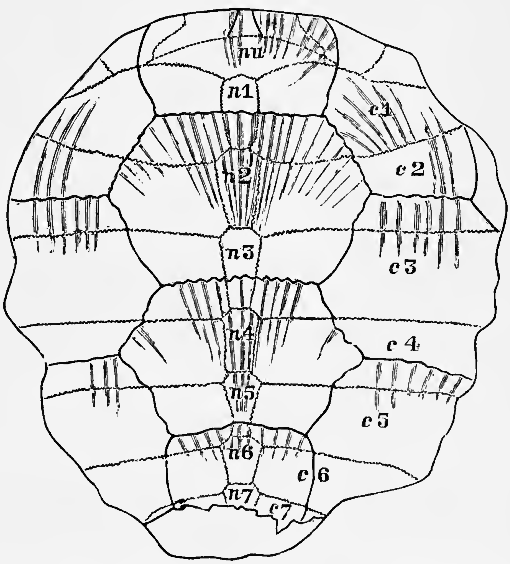


FIG. 55.—The imperfect carapace of *Plesiochelys valdensis* (Lydekker); Wealden, Isle of Wight (¼ nat. size). *nu*, nuchal bone; *n*1–*n*7, neural bones; *c*1–*c*7, costal bones.

TERTIARY AND SECONDARY CHELONIA.

The collection is particularly rich in remains of Chelonians from the Purbeck beds of Swanage, Dorset, the Chalk, Gault, and Greensand of England, the Maestricht beds of Holland, the Eocene Tertiaries of Harwich, Sheppey, Hampshire, the Isle of Wight, and other localities.

The last surviving species of Chelonian indigenous to England was the Marsh Tortoise, *Emys orbicularis*, Linn., whose remains have been found in fluviatile deposits of Post-Pliocene age at Mundesley and East Wretham Fen, in Norfolk (*see* "Geol. Mag." 1879, p. 304), once common over a large part of Europe and still living in the South of Europe, in Asia and Algeria.

Some of the old gigantic land-tortoises (of which a few only survive) inhabited Mauritius, the Seychelles, and other islands

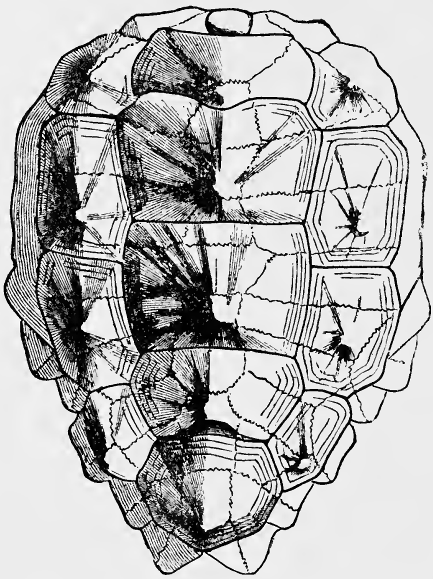


Fig. 56.—Dorsal aspect of the carapace of *Platychelys Oberndorferi* (Wagner). Lithographic stone (=Lr. Kimmeridgian), Kelheim, Bavaria. $\frac{1}{3}$ nat. size.

of the Indian Ocean and the Galapagos Islands in the Pacific. Like the Dodo, they have been gradually exterminated by the hand of man.

Two fine specimens of a very large extinct land-tortoise (*Testudo Grandidieri*) obtained from Cave-deposits in S.W. Madagascar are exhibited in Table-cases, Nos. 20 and 21.

Chelonia. West Corridor, No. 5 on Plan.

The largest of the fossil forms (a restored cast of which is placed on a stand in the centre of Narrow Gallery No. V) is the *Testudo* from the Siwalik Hills of India. The detached fragments of this great carapace are placed in the Wall-case. These old land-tortoises, so remarkable for the magnitude they **Wall-case No. 12.**

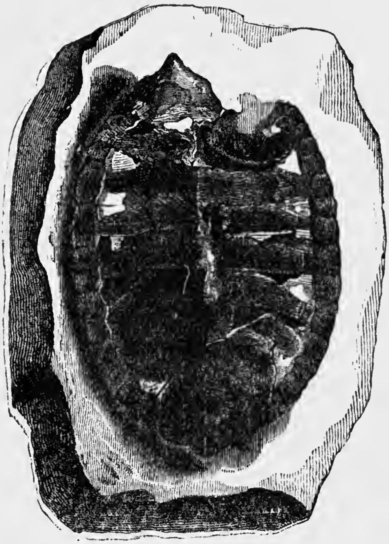
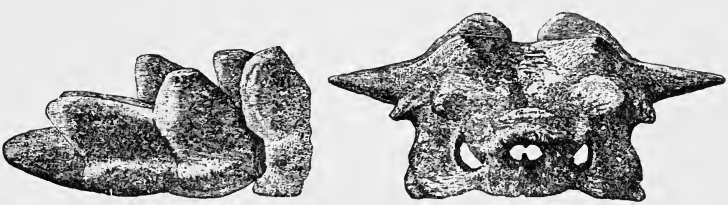


FIG. 57.—Carapace of *Chelone* (?) *Benstedi* (Mantell); Lower Chalk, Burham, Kent. (Figured in "Phil. Trans.," 1841, pls. XI and XII.)

attained, had extremely long necks and small heads; they were all vegetable-feeders.

Several smaller species of Chelonians are also exhibited from the same Indian locality. **Wall-case, No. 11.**



B A

FIG. 58.—A, The Skull, and B, the Tail-sheath of the great Horned Chelonian, *Miolania Oweni* (A. S. Woodw.), from the Newer Tertiary deposits of Australia. Much reduced.

In Wall-case 11, are placed the remains of a remarkable extinct Chelonian, named *Miolania Oweni*, from Australia, having nine horn-like prominences on its skull, which measured **Miolania Oweni.**

Wall-case, No. 11.

1 foot $10\frac{1}{2}$ inches in breadth. The skull, at first glance, looks like that of some flat-headed form of ox; but the bones are altogether dissimilar, and the jaws are without teeth.

Other remains were sent over in 1880, showing that it possessed a tail encased in a horny sheath (*see* Fig. 58, B), so like the armour-plated tail of the great extinct non-banded Armadillo *(Glyptodon)* from South America, that had the tail arrived before the head and vertebræ had been received, it might well have been cited to prove the former existence of the *Glyptodon* in Australia (*see* "Phil. Trans." 1858, 1880, and 1881). Still further evidence of another species of horned Chelonians, named *Miolania platyceps* by Owen, has been obtained from a coral sandstone formation on Lord Howe Island, 700 miles from the coast of Australia, whence the first specimens were obtained.

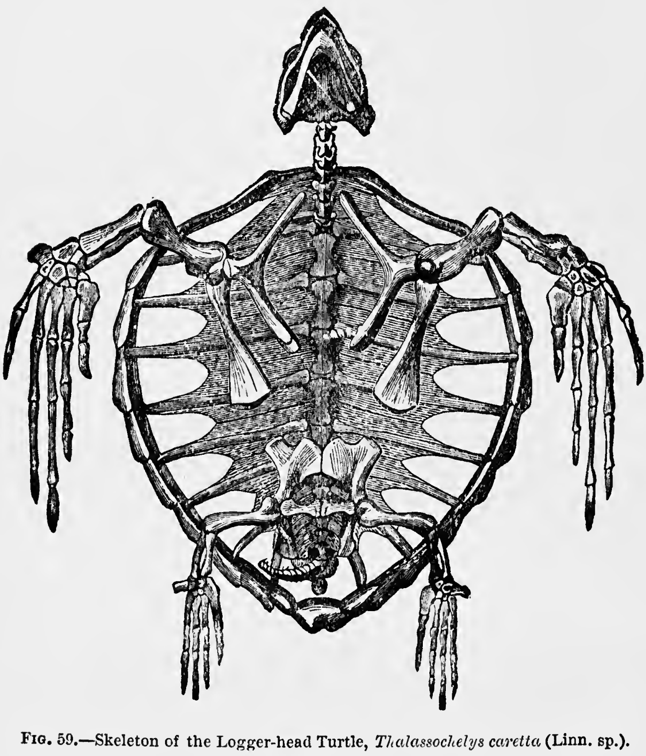


FIG. 59.—Skeleton of the Logger-head Turtle, *Thalassochelys caretta* (Linn. sp.).

Eosphargis. Wall-case, No. 12.

Here are placed the remains of the great *Chelone Hoffmanni*, from the Chalk of Maestricht. The *Eosphargis gigas*, whose head and some other parts of the skeleton may be seen and compared, is from the London Clay of Sheppey, and represents a still larger form related to the living Leathery Turtle. These were true marine turtles, like the "Loggerhead" Turtle of the present day (Fig. 59). **Wall-case, No. 12.**

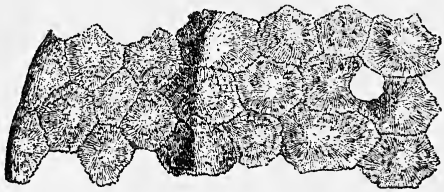


FIG. 60.—Fragment of Carapace of *Psephoderma alpinum*, Meyer; Trias, Bavaria (¼ nat. size).

The oldest Chelonians known are the *Chelytherium obscurum*, Meyer, and *Proganochelys Quenstedti*, Baur, from the Triassic sandstones, Stuttgart. **Wall-case, No. 11.**

Of the fifty-two genera and one hundred and thirty-one species or varieties of fossil Chelonians named in the collection, only eighteen genera and ten species can be with certainty correlated with living forms; whilst for the reception of a few of the more remarkable extinct forms, such as *Miolania* and *Pelobatochelys*, special families have been constituted.

Order IX.—SAUROPTERYGIA.

Gallery IV. Wall-cases, 9, 10, 13. Table-cases, 6, 7, 8.

In this extinct order the body has no exoskeleton; the neck is more or less elongated, and the tail short. In the skull the nares, or nostrils, are lateral and placed near the orbits. The premaxillæ are very large, and there is a well-developed parietal foramen in the adult. The symphysis of the mandible is united by a suture (Fig. 63). The teeth are implanted in distinct sockets and confined to the margins of the jaws; they have curved sharp crowns with fluted enamel. Each rib articulates to a single vertebra; the facets for the cervical ribs may be either single or double, and are situated entirely on the centrum. The vertebræ are amphicœlous (concave at both ends). The neck may have as many as from 21 to 44 vertebræ. A few of the vertebræ behind the cervicals have the ribs articulating partly on the arch and partly on the centrum: these have been named pectoral vertebræ. The ribs attached to the dorsal vertebræ have the articulation entirely on the arch, which generally forms an elongated transverse process. The

Wall-case, No. 13.
Table-cases, Nos. 6, 7, 8.

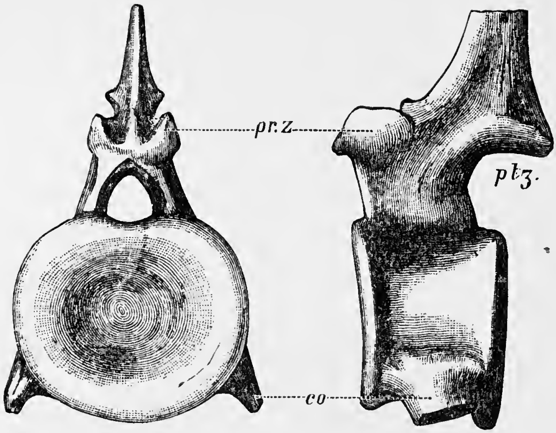


Fig. 61.—Anterior and left lateral aspects of a cervical vertebra of *Cryptoclidus* (?) *Richardsoni* (Lydekker) from the Oxford Clay, Weymouth, Dorset. ½ nat. size, *co*, rib; *prz*, prezygapophysis; *ptz*, postzygapophysis.

caudal vertebræ carry true ribs and also chevron bones. In the pectoral girdle, the coracoids unite in a ventral symphysis, and the scapulæ may also meet in the median line. The limbs

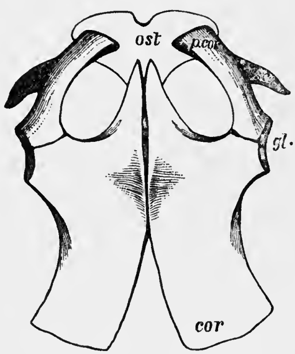


Fig. 62.—Ventral aspect of the pectoral girdle of *Plesiosaurus Hawkinsi* (Owen), from the Lower Lias, Street, Somerset (about ¼ nat. size) *ost.*, clavicular arch; *sc.*, scapula; *pcor.*, ventral (precoracoidal) plate of scapula; *gl.*, glenoid cavity; *cor.*, coracoid. (In reality the clavicular arch is wedged in between the extremities of the coracoids.)

vary, being in some genera adapted for progression on land, in others converted into paddles suited for an aquatic existence. The humerus and femur are always of considerable length; the phalangeal bones are elongated, but no additional digits are developed. In habits the members of this order were carnivorous, and either marine or terrestrial.

PLESIOSAURIDÆ.—In Wall-cases Nos. 9 and 10, and in Table-case No. 6, are placed the remains of one of our largest marine reptiles, the *Pliosaurus*, from the Kimmeridge Clay, near Ely, and also from Dorsetshire. We have no entire skeleton of this animal, but the cast of a swimming-paddle (the original of

Pliosaurus. Wall-case, No. 13. Table-case, No. 6.

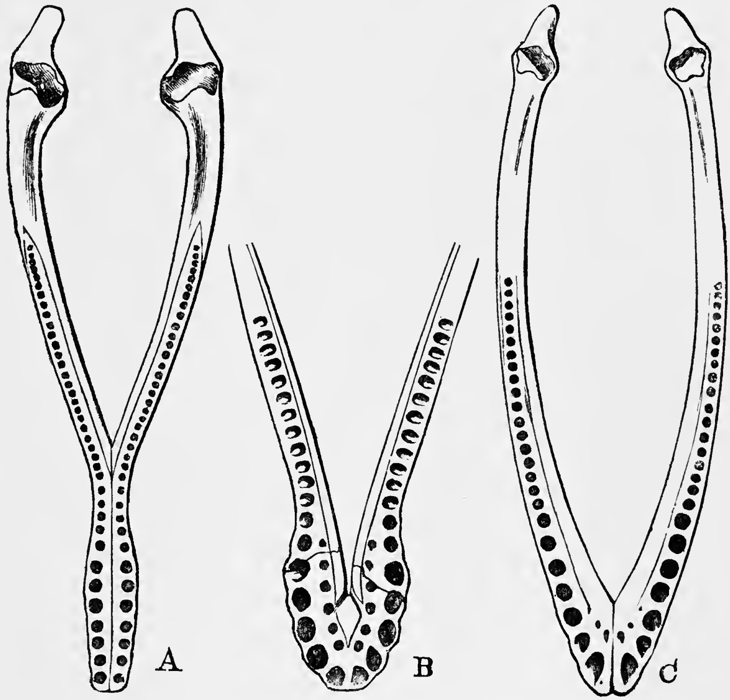


FIG. 63.—Sauropterygian mandibles. A, *Peloneustes philarchus* (Seeley); from the Oxford Clay, 1/8. B, *Thaumatosaurus indicus* (Lydekker); Upper Jurassic of India, 1/7. C, *Plesiosaurus dolichodirus* (Conybeare); from the Lower Lias, Lyme Regis.

which is preserved in the Dorchester Museum) measures 7 feet in length; its jaw was 6 feet long, and one of its teeth was 15 inches in length. It had a shorter neck than the *Plesiosaurus*, but was probably less fish-like in aspect than *Ichthyosaurus*, which latter reptile it outrivalled in point of size.

In Wall-case No. 13, and in Table-cases Nos. 6, 7, 8, are arranged examples of the extinct group of marine reptiles, the PLESIOSAURIA (*see* Figs. 64, 65, pp. 48, 49). They are distinguished at once by the great development of the neck, which is composed of numerous vertebræ. The head is comparatively small in size; the orbits are large; the limbs being shaped externally

Plesiosaurus. Wall-case, No. 13, and Table-cases, Nos. 6, 7, 8.

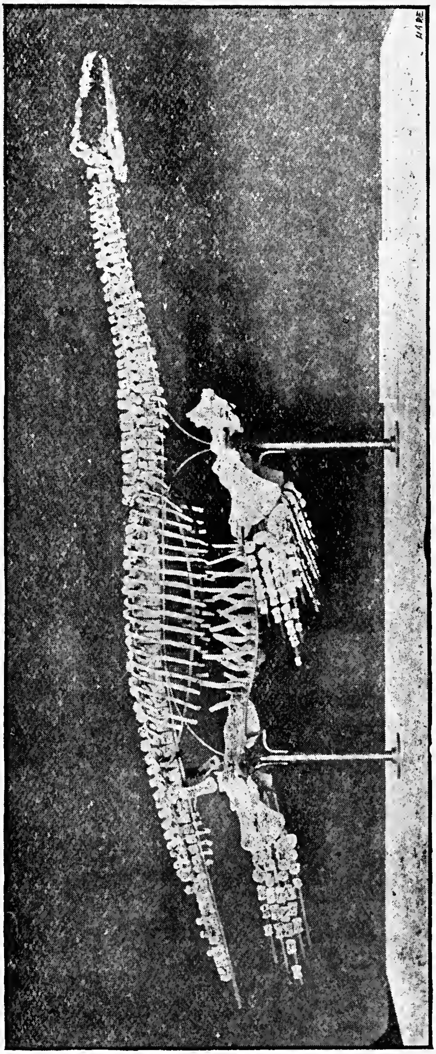


Fig. 64.—*Cryptoclidus oxoniensis* (Phillips, sp.); photograph of immature skeleton six feet in length.—Oxford Clay, Peterborough. [Small Glass-case J.]

(From the Leeds Collection.)

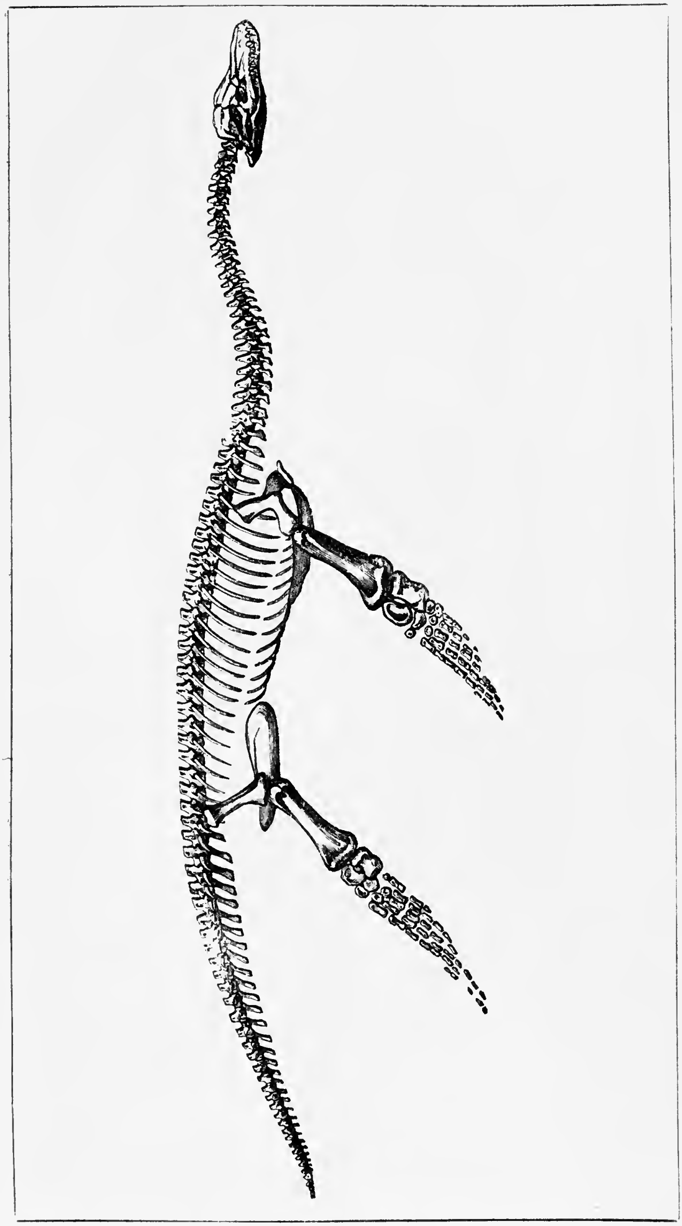


Fig. 65.—Skeleton of the Long-necked Sea-Lizard (*Plesiosaurus*), from the Lias of Lyme Regis, Dorset.
Wall-case, No. 13.

Wall-case, No. 13.
Table-cases, 6, 7, 8.

like the flippers of a whale, and made up of 5 fingers, composed of numerous phalanges. The jaws were armed with many simple pointed teeth inserted in distinct sockets. The most complete examples are the *Plesiosaurus Hawkinsi*, the *Pl.*

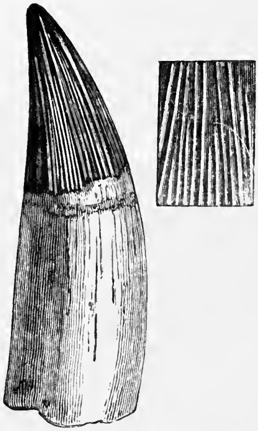


Fig. 66.—A tooth of *Polyptychodon interruptus* (Owen); Greensand, Cambridge.

Fig. 67.—An upper tooth of *Peloneustes philarchus* (Seeley); Oxford Clay, Bedford, $\frac{1}{1}$.

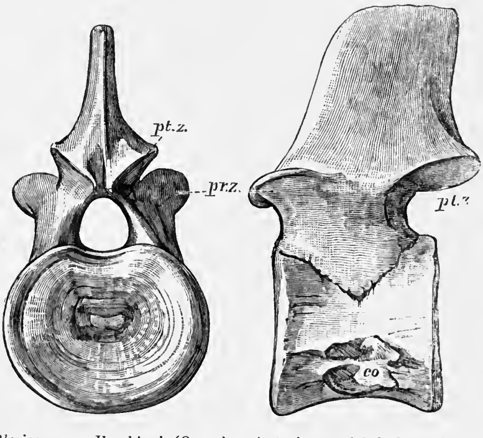


Fig. 68.—*Plesiosaurus Hawkinsi* (Owen). Anterior and left lateral aspect of a late cervical vertebra, from the Lower Lias of Lyme Regis, Dorset; *co*, costal facet; *prz*, prezygapophysis; *ptz*, postzygapophysis.

robustus, the *Pl. laticeps*, *Pl. macrocephalus*, all in Case No. 13; and the cast of the *Thaumatosaurus*, fixed on the wall of the East Corridor (No. 3 on Plan), leading to the S.E. gallery, which is 22′ 0″ in length and 14′ 0″ in breadth, measured across its expanded paddles.

Wall-case, No. 13.

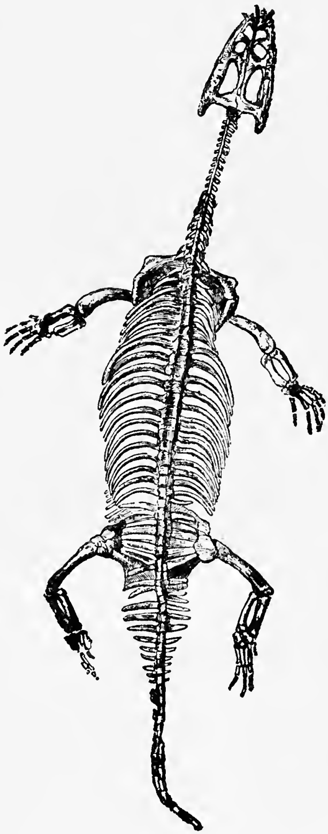


FIG. 69.—Skeleton of *Lariosaurus Balsami* (Curioni); Muschelkalk, Perledo, Lake of Como, Italy ($\frac{1}{8}$ nat. size; original in the Munich Museum). (See coloured reproduction in frame on wall.)

In Wall-case 10 are exhibited numerous more or less complete skeletons of species of the genera *Cryptoclidus*, *Murænosaurus*, and *Peloneustes* from the Oxford Clay of Peterborough (Leeds Collection). In some cases the bones are so little crushed that it has been possible to mount them in their natural position. One nearly complete skeleton of a young Plesiosaur (probably *Cryptoclidus*) from the same locality has been mounted and placed in a separate case in the centre of gallery.

Gallery IV. Glass-case J, centre of floor.

Most of the "Sea-Dragons," both the long and the short-necked forms, were obtained from the Lias of Street, Somersetshire; Lyme Regis, Dorsetshire; Barrow-on-Soar, Leicestershire;

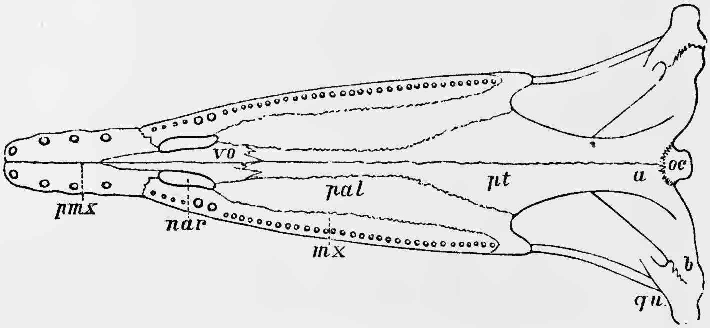


FIG. 70.—Palatal aspect of the cranium of *Nothosaurus mirabilis* (Münster); Muschelkalk, Germany (¼ nat. size). *pmx*, premaxilla; *nar*, posterior nares; *vo*, vomer; *mx*, maxilla; *pal*, palatine; *pt*, pterygoid; *a*, ala of same; *b*, quadratic ridge; *qu*, quadrate bone; *oc*, occipital condyle. The posterior extremity of the palatine was probably formed by a transverse bone, but the suture is not visible. (Table-case, No. 17.)

and Whitby in Yorkshire; or from the Oxford Clay of Peterborough and Weymouth, and the Kimmeridge Clay of Dorsetshire; in fact, their geological and geographical distribution seem to have been almost identical.

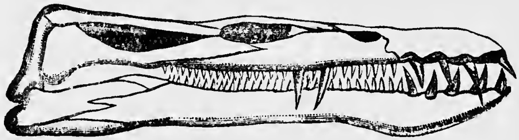


FIG. 71.—Right lateral aspect of the skull of *Nothosaurus mirabilis* (Münster), reduced; from the Muschelkalk of Germany.

Table-case, No. 7.

The LARIOSAURIDÆ, represented by the Italian *Lariosaurus* and the German genus *Neusticosaurus*, appear to connect the marine PLESIOSAURIDÆ with the freshwater and terrestrial NOTHOSAURIDÆ. The skull was short, the neck relatively long; the humerus short, the femur elongated, and the terminal phalangeals were furnished with claws.

Casts of *Lariosaurus Balsami* (Fig. 69) (see coloured cast on wall) and two original and nearly entire skeletons of *Neusticosaurus pusillus* from the Trias of Stuttgart may be seen in the cases.

Table-case, No. 7.

In *Nothosaurus* the skull is long and narrow with the postorbital larger than the preorbital portion and with very long and narrow supratemporal fossæ; the upper teeth are numerous, and the 5th and 6th maxillary teeth much enlarged; the mandibular symphysis is of moderate length and bears 5 teeth; the dorsal vertebræ have very short transverse processes.

Conchiosaurus is closely allied to *Nothosaurus*; *C. clavatus* was about one half the size of *N. mirabilis*. **Table-case, No. 7.**

The genus *Mesosaurus*, a reptile discovered in the Karoo formation, Griqualand, S. Africa, and since met with in Brazil, is included in the same order with *Nothosaurus*. One of the most peculiar features in this genus is the separation of the fourth and fifth tarsalia, so that each metatarsal articulates

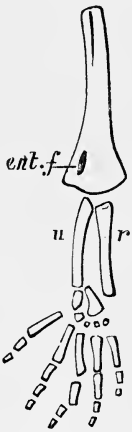


Fig. 72.—Ventral aspect of left pectoral limb of *Mesosaurus tenuidens* (P. Gervais), from the Karoo System (Trias), Griqualand West (South Africa) $\frac{1}{1}$. *ent. f.*, entepicondylar foramen of humerus; *r*, radius; *u*, ulna (*see* Wall-case No. 8).

Fig. 73.—Ventral aspect of right humerus of *Conchiosaurus clavatus* (Meyer); Muschelkalk of Nurnberg ($\frac{1}{2}$ nat. size); *entf*, entepicondylar foramen; *a*, ectepicondylar groove.

with a distinct tarsale. The centra of the vertebræ have a notochordal canal, and are small in comparison to the neural arches; while the ribs were anchylosed to the vertebræ, and were of great thickness like those of *Nothosaurus*. Abdominal ribs were also present. The skull was much elongated, and furnished with slender recurved teeth, implanted in distinct sockets.

Order X.—PLACODONTIA (Plate-toothed Reptiles).

The genus *Cyamodus*, from the Muschelkalk of Germany, offers a remarkable modification in its dentition not usually met with in the reptilian class, but of which the class of fishes affords numerous examples. The skull is as broad as it is long, the greatest breadth being behind, whence the sides converge to an obtuse muzzle. The temporal fossæ are the widest and the zygomatic arches the strongest in the reptilian class, **Cyamodus. Table-case, No. 17.**

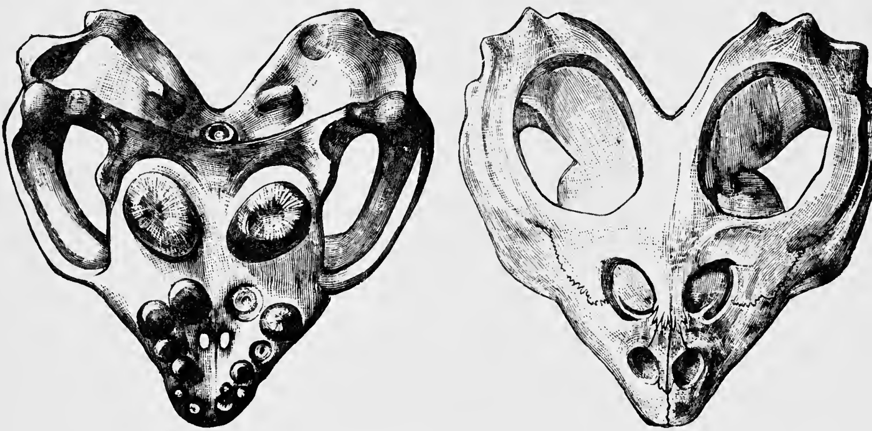
and the lower jaw presents a similar strong development of the coronoid process. This powerful action of the jaws for biting and grinding relates to the form and size of the teeth, which resemble paving-stones, and were evidently adapted to crack the shells of Mollusca, Crustacea, and perhaps Echini also, upon which this reptile probably subsisted.

The upper jaw contains a double series of these teeth, an outer, or maxillary series, and an internal or palatal series; but the under jaw has only a single row of teeth.

Although now admitted to be a reptile, this remarkable genus was formerly classed by Münster and Agassiz as one of the Pycnodont fishes.

Placodus.
Table-case, No. 17.

Placodus gigas (Agassiz). A closely allied form; has a more elongated cranium with a distinct premaxillary rostrum carrying three chisel-like teeth on each side. It has three polygonal



A B

Fig. 74.—*Cyamodus* (*Placodus*) *laticeps* (Owen). A, palatal aspect; B, frontal aspect of cranium; from the Muschelkalk of Baireuth, Germany. (Table-case, No. 17.)

palatine teeth and four or five maxillary ones. The cranium is more elevated than in *Cyamodus*.

Order XI.—ANOMODONTIA.

Wall-cases, Nos. 8, 9.
Table-cases, Nos. 17, 18.

In this order the limbs are adapted for walking. The skull is comparatively short; the quadrate bone is fixed; a parietal foramen is present; there is one temporal arcade; the nasals are large; in the palate the pterygoids meet together in front of the basisphenoid, which they also join, but diverge anteriorly; the palatine bones are small and placed internally to the pterygoids, as in Mammals. The dentition is *thecodont* (teeth placed in distinct sockets), but the teeth may be anchylosed to the bone. The vertebræ are *amphicœlous* (concave at both ends), and in some cases the notochord pierces them; the dorsal vertebræ have long transverse processes, and the anterior ribs articulate by double heads. Abdominal ribs seem generally to have been absent. In the pectoral girdle an interclavicle, clavicles, and precoracoids are present, and a sternum was probably always developed.

In the pelvis the pubis is placed in advance of the ischium to which it is completely united. The body of the ilium is in advance of the acetabulum. The tarsus has one centrale, and the phalangeal bones of the manus and pes are typically 2, 3, 3, 3, 3, in number as in Mammals; the whole structure of the foot being Mammalian in type. We are led to conclude, from recent researches, that these animals are directly descended from the Labyrinthodont Amphibians, more especially from the Archegosaurian family. They are also related in all probability to Monotreme Mammals.

This order appears to be confined to the Permian and Trias.

Sub-order 1.—**Procolophonia.**

Table-case, No. 17.

To the Anomodontia are now referred the small reptiles of the genus *Procolophon*, with a short triangular and somewhat depressed skull; their dentition is carnivorous but the marginal teeth are all alike and are completely anchylosed to the bone; teeth are also borne upon the vomer and the pterygoids. *Procolophon* presents many points of resemblance to *Sphenodon* and the *Rhynchosauridæ*. The genus is met with in the Karoo Beds (Trias), of South Africa.

Sub-order 2.—**Dicynodontia** (Double Dog-toothed).

Dicynodon. Wall-case, No. 9. Table-case, No. 18.

Family Dicynodontidæ.—The Dicynodonts* are a very peculiar family of reptiles from the Trias of South Africa. The skull is massive and remarkable in form, and is furnished with a single pair of huge sharp-pointed tusks growing downwards, one from each side of the upper jaw, like the tusks in the Walrus. No other kind of teeth was developed in these singular animals; but the premaxillaries was confluent and sharp-edged, and formed with the lower jaw a beak-like mouth, probably sheathed in horn like that of the Turtles and Tortoises. Several species have been described from the Storm-

* The genus, *Dicynodon*, is so called from δια, two, and κυνοδος, canine tooth, from the two tusk-like canines in the upper jaw.

Dicynodon.
Wall-case, No. 9.
Table-case, No. 18.

berg and Beaufort Beds of the Karoo series of South Africa, and the equivalent Gondwana series of Central India. *Gordonia* and *Geikia*, closely related to *Dicynodon*, have been discovered in the reptiliferous sandstone of Elgin, Scotland, which seems to be of Triassic age.

Oudenodon.
Table-case, No. 18.

In *Oudenodon* both jaws were edentulous; the maxillæ have a sharp external beak-like ridge; the palate has a vomerine

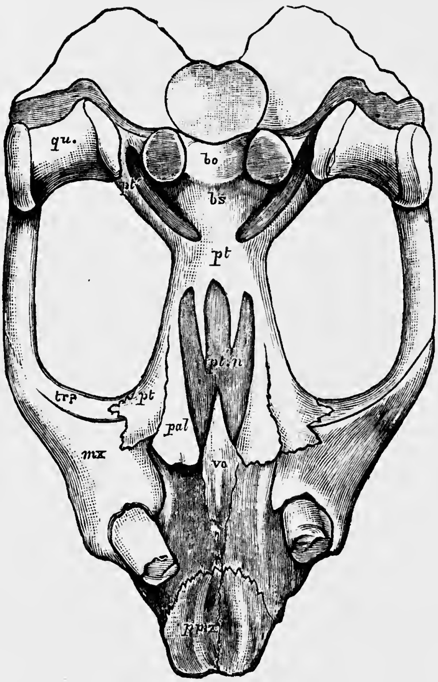


Fig. 75.—Palatal aspect of cranium of *Dicynodon*, from the Karoo series of the Cape of Good Hope, S. Africa. ½. *pmx*, premaxilla; *mx*, maxilla; *vo*, vomer; *pal*, palatine; *pt*, pterygoid; *bs*, basisphenoid; *bo*, basioccipital; *qu*, quadrate; *tr?* transverse bone?; *ptn*, posterior nares. ½ Figure much reduced.

Dicynodon.

ridge, and the general shape of the skull resembles *Dicynodon*. Several species have been described by Owen, all from South Africa.

Table-case, No. 18.
Endothiodon.

Family Endothiodontidæ.– This family includes a number of large reptiles from the Karoo formation of the Cape, of which the genus *Endothiodon* forms the type. They are distinguished from the preceding by the presence of numerous teeth on the palate. The skull resembles *Oudenodon*, but the muzzle is more elongated and the nares (nostrils) are terminal and are overhung by massive nasal bones. The border of the jaws has a cutting edge, but the surface of the palate and

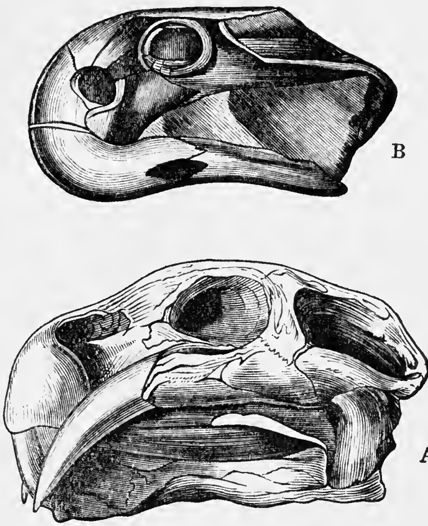


FIG. 76.—Lateral views of the skulls of (*A*), *Dicynodon lacerticeps* (Owen), and (*B*), *Oudenodon Baini* (Owen); from the Karoo series, South Africa. Figures much reduced.

mandible carry one or more longitudinal rows of columnar and cylindrical teeth. The palate of *Endothiodon* is remarkably mammalian in type.

SUB-ORDER 3.—Theriodontia.

Family TAPINOCEPHALIDÆ.—This family includes remains of two large forms from the Karoo beds, South Africa, namely, *Tapinocephalus* and *Titanosuchus*. Their dentition indicates a carnivorous type of reptiles. An imperfect skull, several entire limb-bones, and vertebræ are preserved in the Collection.

Theriodontia. **Table-case, No. 18.** **Wall-case, No. 7.** **Tapinocephalus.**

Family GALESAURIDÆ.—Nearly the whole of the typical Theriodontia are included in this family. They form a remarkable group of carnivorous reptiles, first described and thus named by Sir Richard Owen* in reference to the form and order of arrangement of the teeth bearing a greater resemblance to the dentition of the Mammalia than any other group of the class

Table-case, No. 17. **Galesaurus.**

* "Catalogue of the Foss. Rept. of South Africa," 4to, Lond. 1876.

Reptilia, for, as in the carnivorous mammals, the incisors are separated from the molars by well-developed canines, and the

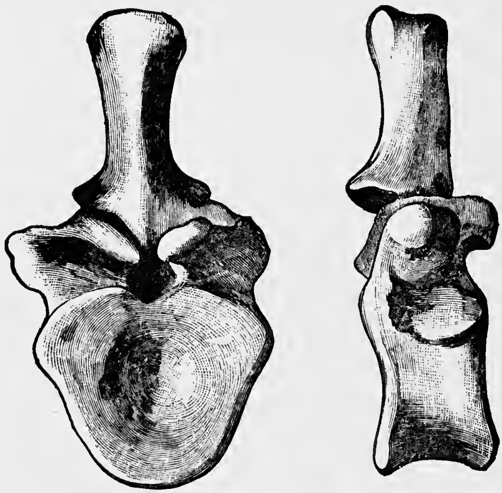


Fig. 77.—Anterior and right lateral aspects of a lumbar vertebra of *Tapinocephalus Atherstonei* (Owen); from the Karoo Beds, South Africa. About ⅓ nat. size.

Table-case, No. 17.

Æluro-saurus.

canines of the lower jaw cross those of the upper in front. In many of the genera the upper canines are long and trenchant, and the incisors large and close together (*Lycosaurus*, *Ælurosaurus*, etc.), the molars, as a rule, being smaller than the incisors. In most reptiles, living and extinct, the teeth that are worn away by use, or otherwise lost, are replaced by others that are constantly

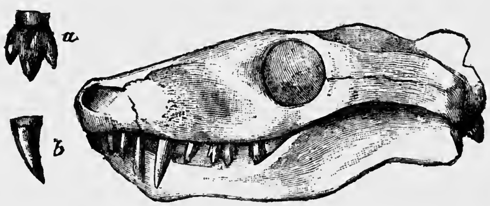


Fig. 78.—Left lateral aspect of skull of *Galesaurus planiceps* (Owen), from the Karoo beds (Triassic), South Africa (⅓ nat. size). *a*, an upper cheek-tooth, and *b*, an incisive tooth.

Teeth of Therio-dontia.

forming in the jaws; but there is no evidence of preceding teeth, like the milk-teeth in mammals, nor of successional teeth, in the jaws of the Theriodonts. From this negative evidence Sir Richard Owen assumes them to have been "Monophyodont" reptiles, having but one set of teeth, which were permanent, during life. He has described eleven genera, varying in the size and form of the skull and teeth. The specimens exhibited have all been obtained from rocks of Triassic age in South Africa, and are the type-specimens of the species figured and described in the work already quoted.

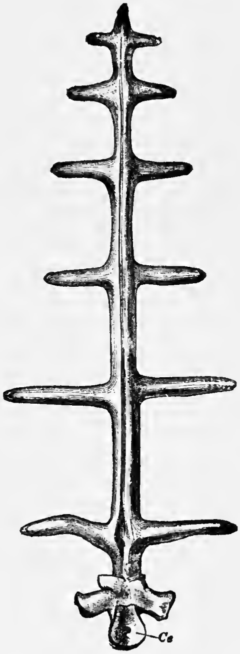


FIG. 79.—Anterior view of a dorsal vertebra of *Naosaurus claviger* (Cope), from the Permian of Texas ($\frac{1}{8}$ nat. size): *ce*, centrum.

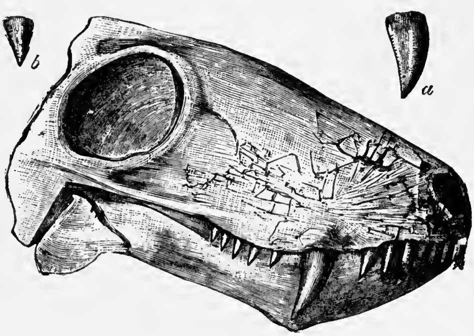


FIG. 80.—Right lateral aspect of imperfect cranium of *Ælurosaurus felinus* (Owen); from the Karoo Beds (Triassic), Beaufort West, South Africa ($\frac{2}{3}$ nat. size). *a*, upper incisive tooth; *b*, upper cheek-tooth, enlarged.

Glass-case No. I., and Table-case, No. 17.

Two very remarkable genera of *Theriodonts*, *Cynognathus* and *Gomphognathus*, have lately been described by Prof. H. G. Seeley. In both the skull is remarkable for its mammalian appearance, that of *Cynognathus* especially, with its small incisors and powerful canines, having a striking resemblance to the skull of a Carnivore, such as the wolf. The occipital condyle is double, also a mammalian character, and the quadrate is much reduced. An imperfect skeleton of *Cynognathus crateronotus* is exhibited in a separate case in the middle of the gallery. *Gomphognathus* is further remarkable for its broad-crowned molar teeth.

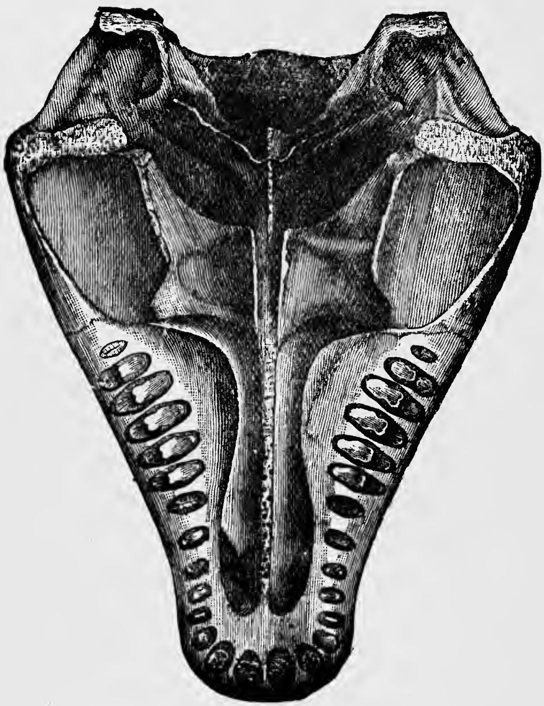


FIG. 81.—Palatal aspect of cranium of *Empedias molaris* (Cope), ½ nat. size; from the Permian of Texas, North America.

Naosaurus.

Family CLEPSYDROPIDÆ.—These Theriodonts differ from the GALESAURIDÆ either in having teeth on the palate, or by the extraordinary character of their dorsal vertebræ, in which large intercentra are typically present. These forms all belong to

Gallery, No. 4. Table-case, No. 18. Empedias.

the Permian formation of North America. The premaxillary and maxillary teeth are of unequal size, as in *Galesaurus*, and there are two tusks near the extremity of the dentary bone. In *Dimetrodon* and *Naosaurus* the neural spines of the dorsal vertebræ have an extraordinary development; the height of the spine in one species being more than twenty times the length of the centrum. Prof. Cope concludes that these spines formed a kind of elevated fin on the back, of which it is difficult to imagine the use. In *Naosaurus* there were horizontal processes on the spines of the vertebræ. This genus has also been recorded from the Permian of Bohemia (*see* Fig. 79, p. 59.)

Family Diadectidæ.—In the Diadectidæ, represented by the genera *Diadectes*, *Empedias*, and *Helodectes*, the teeth are transversely elongated, and are also divided by a median vertical ridge, but both the inner and outer sides are equally low. They are believed to have been herbivorous in diet.

These genera are characteristic of the Permian of North America; *see* Figs. 81 and 82, *Empedias molaris* (Cope).

Family Bolosauridæ.—Another closely related form, referred to the family of Bolosauridæ, named *Deuterosaurus*, is found in the Permian of Russia (Fig. 83).

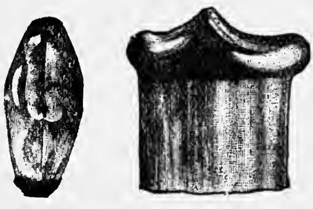


Fig. 82.—Lateral and palatal view of posterior tooth of *Empedias molaris* (Cope); Permian, North America.

Fig. 83.—Lateral view of a premolar of *Deuterosaurus biarmicus* (Eichwald), from the Upper Permian of Russia.

A tooth has been obtained from the Karoo beds of South Africa closely resembling in general characters the anterior teeth of *Deuterosaurus*. It has been made the type of the genus *Glaridodon*.

Sub-order 4.—**Pariasauria.**

Wall-case, No. 9, and Table-case, No. 18.

In this sub-order are placed the remains of several other genera of Anomodonts. They include *Pariasaurus*, *Anthodon*, and *Propappus*, from the Triassic deposits of South Africa.

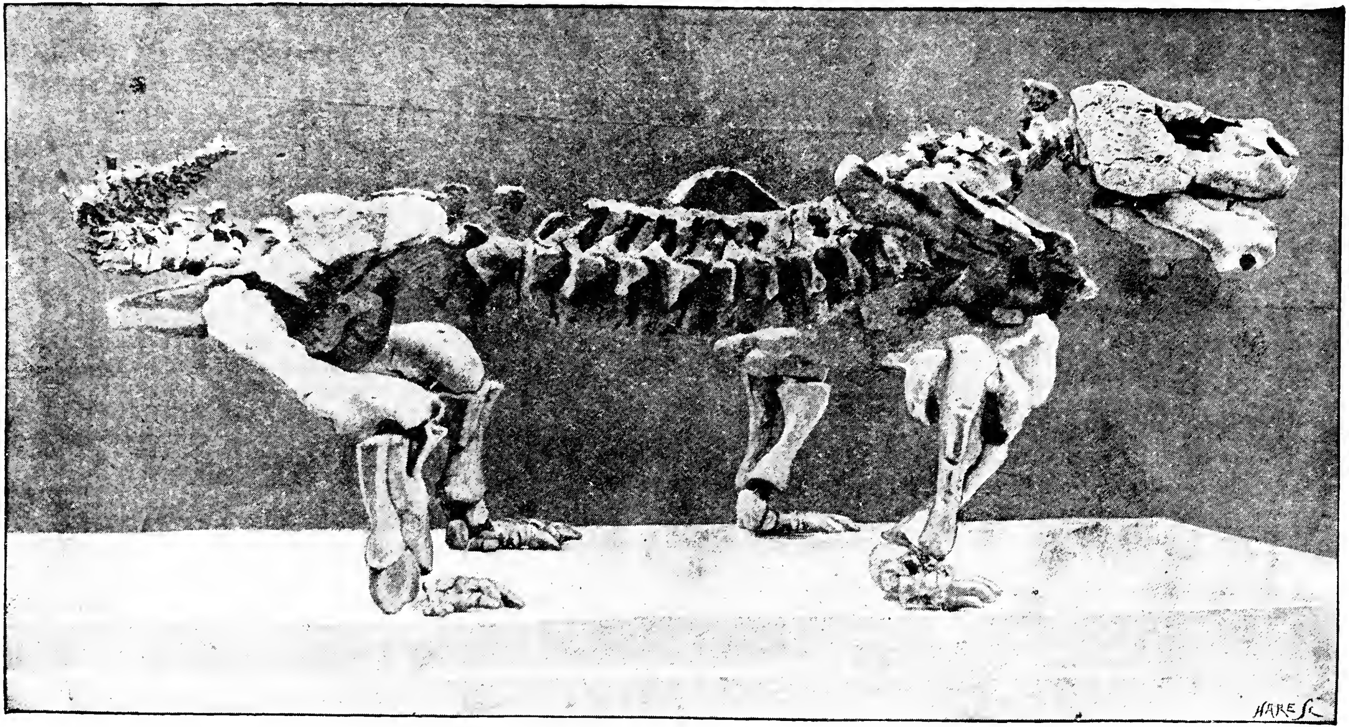


FIG. 84.—SKELETON OF PARIASAURUS BAINII (Seeley).
From the Karoo Formation (Trias), Bad, Tamboer Fontein, Cape Colony.
Presented to the Museum by Prof. H. G. Seeley, F.R.S., F.G.S., &c.
(See Glass-case L, in centre of floor at west end of Reptilian Gallery.)

Pariasaurus bombidens was obtained by Mr. Bain from the reptiliferous Triassic sandstone near the Winterberg, Cape Colony. The teeth are close-set, fused with the bone; they resemble those of the *Iguanodon* in their mode of implantation, and those of the *Scelidosaurus* in their close arrangement and nearly uniform wear. The degree of abrasion indicates, as in the *Iguanodon*, that they were applied to the mastication of vegetable substances.

Gallery, No. 4. Pariasaurus. Glass-case, zz. Wall-case, No. 9.

Fifteen or sixteen teeth are closely set on each side of both the upper and lower jaws. As in man, there is no diastema in the dental series, no one tooth is longer than the rest. But there is still greater uniformity in the teeth of this ancient reptile. There is absolutely no character by which to separate the incisors, or canines, or false or true molars. All the teeth are equally worn, and show by their abraded border that they have taken an equal share in the pounding as well as the cropping of the vegetable food upon which the animal subsisted. It may be added that the palate also bears several rows of small teeth.

The animal measures fully nine feet in length, and the shape of its skull and jaws are remarkably like those of the Labyrinthodont Batrachia.

Two examples of the skeleton of *Pariasaurus* are exhibited in a glass-case (marked *K*), at the west-end of Gallery, No. 4.

A still finer skeleton of another species, *P. Baini* (Seeley), from the Karoo Formation of Tamboer Fontein, Cape Colony, is placed in Glass-case *L.* (Fig. 84).

Professor Seeley concludes that this very remarkable and Amphibian-like reptile is a direct descendant from the Labyrinthodonts; the chief affinities to that group being displayed in the characters of the skull, in the notochordal canal, and the large arches of the vertebræ, as well as in the characters of the pectoral and pelvic girdles. The latter features, together with the general structure of the palate, being identical with those of typical Anomodonts, there appears every reason for referring this family to a sub-order of that group.

Class 4.—AMPHIBIA.

Amphibia. Gallery, No. 4. Table-cases, Nos. 22 and 23.

West Corridor, No. 5. Wall-case, No. 11.

In Wall-case No. 11, and in Table-cases Nos. 22 and 23, are placed the fossil Amphibia or Batrachia (Frogs, Toads, Newts, and Salamanders). These animals are distinguished from true reptiles by the fact that the young undergo certain metamorphoses after leaving the egg. In this stage of their existence they breathe by external gills, which are occasionally retained along with internal lungs in the adult animal. The limbs are sometimes all absent, or one pair may be wanting. When present, they have the same bones as in the higher animals; they are never converted into fins. The skull has two occipital condyles and often a persistently cartilaginous basi- and supra-occipital. The suspensorial apparatus of the mandible is continuous with the skull. Teeth are commonly present on the premaxilla, maxilla, vomer, and the dentary bone of the mandible. They are usually anchylosed to the bone and are simple in structure; but in the Labyrinthodonts they are more complex. There are never more than two vertebræ coalesced to form the sacrum. The tail is usually comparatively short. The centra of the backbone are sometimes found to be unossified, forming a mere ring of bone, the interior being gelatinous. This form of backbone is called "Notochordal," and is characteristic of the oldest forms belonging to this group met with fossil in the Coal Measures, such as the *Anthracosaurus*, *Archegosaurus*, and the Triassic Labyrinthodonts.

Order I.—ECAUDATA. (Tailless Batrachia, Frogs and Toads.)

Table-case, No. 23. Batrachia; Frogs, Toads.

The body of the adult is short, destitute of a tail, and furnished with four limbs, of which the pelvic pair are the larger and adapted for leaping. There are no gills in the adult. Skull short and wide, with the parietals confluent with the frontals, and the orbits usually undefined; præsacral vertebræ few in number, and generally procœlous; there is only one sacral vertebra, and the vertebral column terminates in a long urostyle; dorsal ribs are usually absent. Ilia prolonged backwards, so as to throw the acetabulum far behind the sacrum; radius and ulna, and tibia and fibula respectively fused together, calcaneum and astragalus elongated. Four digits in the hand and five in the foot; an additional ossicle in the pes may represent the prehallux.

The tailless Batrachia (frogs and toads) do not date back further in time than the Upper Eocene.

A form allied to the European genus *Bombinator* occurs in the Upper Miocene of Switzerland and the Middle Miocene of Sansan, France. Another genus *Bufavus*, occurs in the Middle Tertiary of Italy. *Pelobates* is found in the Miocene of Sansan, and *Protopelobates* in that of Bohemia. The extinct family of *Palæobatrachidæ* has teeth in the upper jaw and no ribs; it was widely distributed over the continent of Europe in Miocene times, and was represented by a single genus *Palæobatrachus*, and more than a dozen species from various localities.

Table-case, No. 23.

Batrachia; Frogs, Toads.

The true toads, *Bufonidæ*, have no teeth or dorsal ribs. Existing species of the genus *Bufo* occur in the European and Indian Pliocene deposits. *B. Gesneri* from the Upper Miocene of Switzerland agrees closely with the living *B. viridis*. Dr. Filhol records the type-genus from the Upper Eocene Phosphorites of France.

The huge *Ceratophrys cornutus*, or Horned Frog of Brazil, occurs in the Cave deposits of that country; and the genus *Latonia* in the Miocene of Switzerland.

The *Ranidæ*, or true frogs, have teeth in the upper jaw and the extremities of the sacral ribs are not expanded. Species of *Rana* are found in the Norfolk Forest Bed, in the Pleistocene of Sardinia, the Miocene of Sansan; two are from the Brown Coal of Rott, near Bonn, others from the Upper Eocene Phosphorites of Caylux, France; several forms occur in the Middle Tertiary of Italy, &c.

Order II.—CAUDATA. (Salamanders, &c.)

In this order the body of the animal resembles that of a Lizard, or is still more elongated like that of an Eel; in some there are four limbs present, in others only the anterior pair are

Wall-case, No. 11.

Table-case, No. 23.

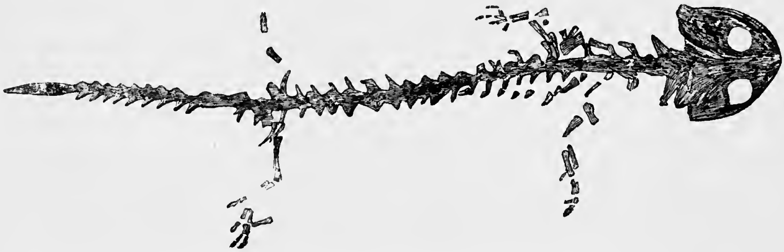


Fig. 85.—The great Fossil Salamander *Megalobatrachus* (*Cryptobranchus*) *Scheuchzeri* (Holl), from the Upper Miocene, Œningen, Switzerland.

developed. The external gills of the larva are occasionally retained in the adult animal. *Hylæobatrachus* is found in the Wealden of Belgium and may be an ancestral form allied to the *Proteidæ* but distinguished by the presence of a maxilla and of five digits to the feet. (The only specimen known is in the Brussels Museum.)

Salamanders.

In the family of *Amphiumidæ* is placed *Megalobatrachus*

Wall-case, No. 11.

(*Cryptobranchus*) represented by the gigantic Salamander (*M. maximus*) of China and Japan, with which we may probably include the large Salamander from the Upper Miocene of Oeningen, Switzerland, originally regarded as the remains of a fossil man, and described by Scheuchzer as "*homo diluvii testis*," the man who witnessed the Deluge!

Table-case, No.23.

Cryptobranchus Tschudii (Meyer) a much smaller form than *C. maximus*, but with a skull of nearly the same form, is from the Miocene Brown-coal beds of Rott, near Bonn, in the Siebengebirge.

The true Salamanders lose their gills when adult, but in some individuals of *Amblystoma* they are persistent. The existing crested Newt (*Molge cristata*) is found in the Norfolk Forest-bed, other representatives occur in the Middle and Lower Miocene of Europe. *Chelotriton* is found in the Lower Miocene of Allier; *Heliarchon* in the Brown Coal of Bonn; and *Megalotriton* in the Upper Eocene Phosphorites of Central France.

Order III.—LABYRINTHODONTIA.

Wall-case, No. 11.

Table-cases, Nos. 22, 23.

In this order the body is long and lizard-like (occasionally snake-like) in form, with a tail, the pectoral limbs shorter than the

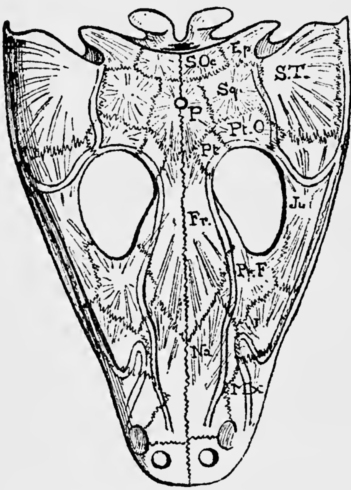


FIG. 86.—*Mastodonsaurus giganteus* (Jaeger), from the Lettenkohle (Lowest Keuper) of Würtemberg; about ⅛. Frontal aspect of the cranium with the sculpture omitted; *SOc* supraoccipital; *Ep*, epiotic; *P*, parietal; *Sq*, squamosal; *ST*, supratemporal; *Q.J*, quadratojugal; *Ju*, jugal; *Pt*, postfrontal; *PtO*, postorbital; *Fr*, frontal; *Pr.F*, prefrontal; *L*, lachrymal; *Na*, nasal; *Mx*, maxilla; the premaxilla has no letter. (After E. Fraas.)

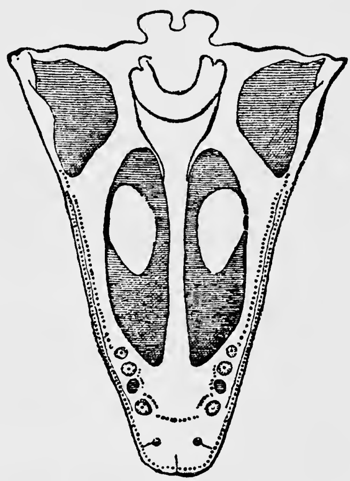


FIG. 87.—Palatal aspect of cranium of *Mastodonsaurus giganteus* (Jaeger); from the Lower Keuper of Würtemberg. (After Miall.)

Wall-case, No. 11.

Table-cases, Nos. 22, 23.

pelvic pair; the feet pentadactyle. Skull with the temporal region completely roofed over by the post-orbital and supra-temporal bones; with a parietal foramen. Teeth pointed, having a large pulp-cavity and the dentine simple or plicated. Vertebræ amphicœlous; they may be imperfectly ossified, and a notochordal canal is often present. A bony thoracic buckler on the ventral aspect. Bony scutes frequently present on the ventral aspect of the body. Teeth are generally present on the palatines and vomer and more rarely on the pterygoids. There is generally an ossified sclerotic ring.

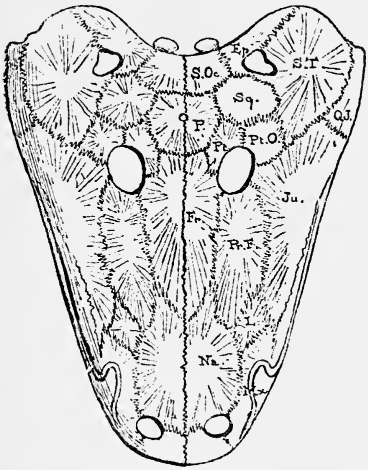


Fig. 88.—Frontal aspect of cranium of *Capitosaurus robustus* (Meyer); Middle Keuper (Upper Trias), near Stuttgart, Würtemberg. Letters as in Fig. 86. ($\frac{1}{3}$ nat. size.)

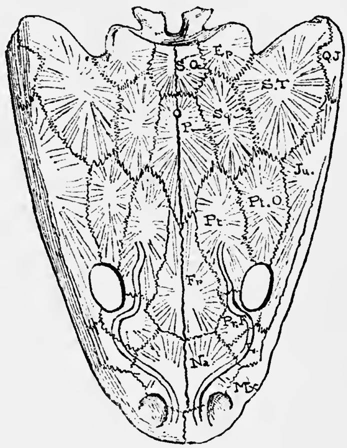


Fig. 89.—Frontal aspect of the cranium of *Metoposaurus diagnosticus* (Meyer), Upper Trias, near Stuttgart. Letters as in Fig. 86. ($\frac{1}{6}$ nat. size.)

The Labyrinthodonts were frequently of large size; the dentine of the teeth was usually plicated; the cranial bones were deeply sculptured and usually marked by numerous mucus-canals.

The Labyrinthodonts range from the Carboniferous to the Trias, and were especially abundant in the Permian epoch.

One of the largest of these forms is the *Mastodonsaurus giganteus* (Jaeger), from the Keuper of Würtemberg, the skull of which measures a yard in length, and broad in proportion; the snout is obtuse, the nares are oval and widely separated; the orbits are oval, but narrow in front, and are some distance in advance of the parietal foramen (*see* Fig. 86).

Wall-case, No. 11.

Capitosaurus and *Metoposaurus* occur in the Upper Trias of Stuttgart; in the former the orbits are elliptical, and approximate to the parietal foramen; in the latter they are oval, and situated in the anterior half of the skull, and widely separated from one another. (Figs. 88, 89.)

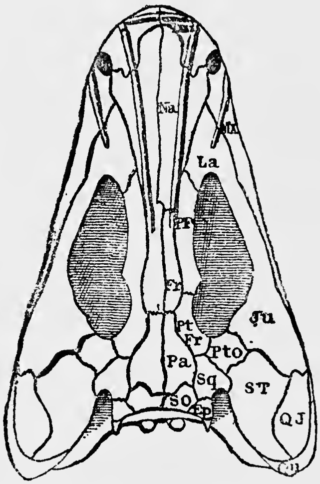


FIG. 90.—*Loxomma Allmani* (Huxley). Frontal aspect of cranium with the sculpture omitted; from the Carboniferous of Northumberland. About $\frac{1}{5}$. *PF*, prefrontal. Other letters as in Fig. 86. (After Miall.)

In the *Anthracosauridæ*, represented by *Loxomma*, the skull is vaulted with a broad and somewhat spatulate muzzle; the length of skull being about 14 inches by 9 inches in breadth. In this family the vertebral column is fully ossified in the adult; the teeth are deeply infolded; the mucus-canals between the orbits and the nares form a lyre-shaped pattern, known as the *lyra*; and the ventral surface of the body typically has a covering of bony scutes.

Loxomma.

Wall-case, No. 11.

In Wall-case 11 is placed a very beautifully preserved skull of a Labyrinthodont from the Coal Measures of Shropshire, referred to *Loxomma Allmani* (Huxley). The specimen is preserved uncrushed and shows the natural contour of the skull and lower jaw, admirably preserved in clay-ironstone. It was presented by George Maw, Esq., F.L.S., F.G.S.

This family comprises *Baphetes*, from the Carboniferous of Nova Scotia; *Anthracosaurus* and *Loxomma*, from the Lower Carboniferous of Burdiehouse, near Edinburgh, and the Coal Measures of Lanarkshire and Northumberland; *Macromerium*, from Bohemia; *Eosaurus*, from Nova Scotia; *Nyrania*, from Bohemia; *Ichthyerpetum*, from Jarrow Colliery, Kilkenny; *Den-*

drerpetum, from the Coal Measures, Nova Scotia; *Brachyops*, from the Permian, Mangali, India; *Bothriceps* and *Micropholis*, from South Africa. **Table-cases Nos. 22 and 23.**

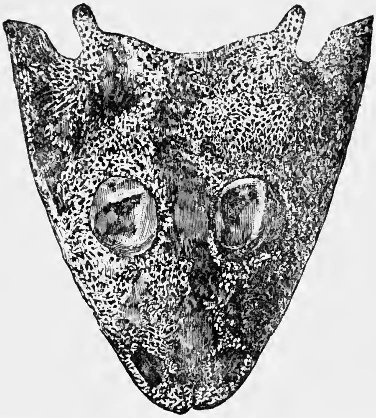


FIG. 91.—*Bothriceps Huxleyi* (Lydekker). Frontal aspect of the skull; from the Karoo system of the Orange Free State, South Africa. $\frac{4}{5}$.

In *Bothriceps* the surface of the cranium is closely and irregularly pitted; the orbits are placed near the middle of the skull. This small skull measures about $2\frac{1}{4}$ inches in length, and 2 in breadth. It was obtained from the Karoo beds (Triassic?) of South Africa.

In the *Diplospondylidæ* the vertebræ, at least in the caudal region, consist of an anterior centrum carrying the neural arch, and a posterior intercentrum to which the chevrons are united. These intercentra correspond with those of *Clepsydrops* among the Anomodontia, the type of structure being known as *embolomerous*.

In the *Archegosauridæ* each vertebra of the trunk, in *Trimerorachis* and *Archegosaurus*, consists of four portions,* namely, a basal intercentrum (hypocentrum), a pair of pleurocentra, and a neural arch. This is known as the *rhachitomous* type of vertebra. These are Labyrinthodonts of moderate size, having cylindrical teeth of varying size with only slight infoldings of the dentine; the upper surface of the skull being pitted; the supra-occipitals ridged; a ring of bones is usually developed in the sclerotic; the ventral surface of the body is always covered with scutes. This family is evidently the most primitive one of the entire group. **See Table-case, No. 23.**

* *See* Fig. 94, infra, p. 71, vertebra of *Euchirosaurus*, illustrating this rhachitomous type of vertebra.

Wall-case, No. 11.

The genus *Archegosaurus*, represented by *A. Decheni* (Goldfuss), from the Lower Permian "Rothliegendes" of Saarbrück, Rhenish Prussia, is particularly well represented in the Collection by a remarkably good series of examples. This genus is confined to the Permian formation, and may be taken as the type of the family. The skull is nearly twice as long as it is broad, with elongate-oval orbits, and situated very far back; length of skull 11 inches. (See Fig. 93, p. 71.)

In *Actinodon* the skull is short and wide, with the circular orbits placed in the middle of the length; the nostrils are large and widely separated; the muzzle is broad. A skull of this species is preserved in the Collection on a slab of shale from the Lower Permian of Autun, Saône-et-Loire, France, and a cast of an entire skeleton from the same locality, presented by Prof. A. Gaudry, is exhibited in the Wall-case.

Cochleosaurus, *Gaudrya*, *Chelyosaurus*, and *Sparagmites*, are Labyrinthodonts from the Permian Gas-coal of Bohemia, discovered and described by Dr. Fritsch, of Prague. *Trimerorhachis* is from the Permian of Texas. *Eryops* occurs in Texas, and perhaps also in South Africa. *Rhytidosteus* is from the Orange Free State (see Table-case, No. 22); and *Pholidogaster* from the Lower Carboniferous of Edinburgh.

FIG. 92.—*Actinodon latirostris* (Jordan, sp.).—Frontal aspect of the cranium, with the sculpture omitted; from the Lower Permian of Saarbrück. ⅔ *Pt.F.*, postfrontal, *Pmx*, premaxilla; other letters as in Fig. 86 (p. 66).

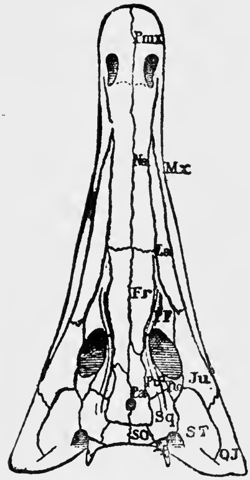


FIG. 93.—*Archegosaurus Decheni* (Goldfuss).—Frontal aspect of the cranium, with the sculpture omitted; from the Rothliegendes (Lower Permian) of Saarbrück. About $\frac{1}{4}$. *Pmx*, premaxilla; *Mx*, maxilla; *Na*, nasal; *La*, lachrymal; *Fr*, frontal; *PF*, prefrontal; *Pa*, parietal; *Ptf*, postfrontal; *PtO*, post-orbital; *Ju*, jugal; *QJ*, quadratojugal; *Sq*, squamosal; *ST*, supratemporal; *Ep*, epiotic; *SO*, supraoccipital. (*After Miall.*)

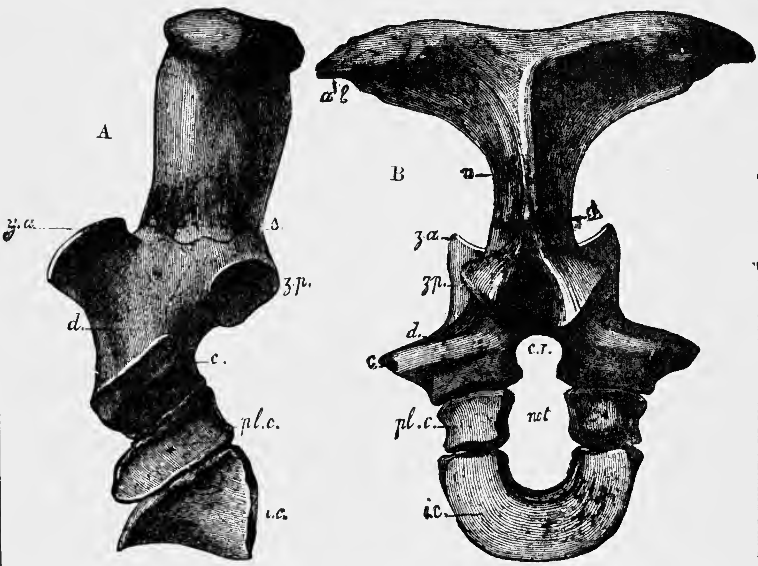


FIG. 94.—A, Left lateral aspect; B, posterior aspect of a vertebra of *Euchirosaurus Rochei* (Gaudry), from the Lower Permian of France. *n*, Neural spine with lateral expansions, *al*; *s*, suture between spine and arch; *za*, prezygapophysis; *zp*, postzygapophysis; *d*, transverse process; *c*, rib facet; *cr*, neural canal; *ic*, intercentrum; *plc*, pleurocentra (illustrating the rhachitomous type of vertebra). (*After Gaudry.*)

Sub-order 1.—Microsauria.

Wall-case, No. 11.
Table-case, No. 22.

This sub-order contains a number of salamander-like forms of Labyrinthodonts referred to the family *Urocordylidæ*, and to the genera *Urocordylus*, *Ceraterpetum*, *Lepterpetum*, from Kilkenny, Ireland, and from Bohemia. *Limnerpetum*, from Bohemia, occupies a family by itself. The *Hylonomidæ* include *Hylonomus*, *Seeleya*, *Ricnodon*, *Orthopleurosaurus*, all from the Gas-coal of Bohemia. *Microbrachis*, also from Nyran, Bohemia, occupies a distinct family. Most of these are represented by electrotypes of the original fossils, the shales in which they occur as fossils being charged with pyrites, which rapidly decompose.

Sub-order 2.—Aistopoda.

Wall-case, No. 11.
Table-case, No. 22.

In this sub-order the body is snake-like without legs, and there is neither a pectoral nor pelvic girdle; the centra of the vertebræ are elongated, and the neural spines aborted. It includes *Dolichosoma* and *Ophiderpetum* (Huxley) from the coal of Ireland and the Permian of Bohemia.

Sub-order 3.—Branchiosauria.

These are short-tailed salamander-like Labyrinthodonts with barrel-shaped centra, and a notochordal canal through their vertebræ.

Table-case, No. 22.

The family Apateonidæ includes *Melanerpetum* from Bohemia; and the family Protritonidæ the genera *Protriton* of Gaudry, from the Lower Permian of Autun, and Bohemia, *Sparodus* and *Dawsonia* also from the last-named locality.

Wall-case, No. 11.

Among doubtful Labyrinthodonts may be recorded here, *Lepidotosaurus Duffii* from the Middle Permian of Midderidge, Durham. Some of the *Ichnites* (Footprints) were doubtless made by Amphibians; they are mentioned under that head in Gallery No. 11 (see *infra*, p. 73 of this Guide, Fig. 95).

FOOTPRINTS.—GALLERY No. 11.

Footprints.

Wall-cases Nos. 8–10 are occupied by a fine series of Footprints and impressions mostly found in Sandstone of Triassic age. Attention is directed to the large slab from near Greenfield, Massachusetts, which is covered with impressions supposed to be the footmarks of bipedal reptiles; these tracks are called "*Ichnites.*"

The *Cheirotherium* footprints in Wall-case No. 10 are exceedingly fine; they occur chiefly in the Triassic Sandstones of Cheshire.

Gallery No. 11. Footprints. Saurian Collection.

Wall-cases, Nos. 11–13, contain a continuation of the Saurian Collection. No. 11 is devoted to the Genus *Plesiosaurus*, Nos. 12 and 13 to *Ichthyosaurus*. Many of these specimens have been figured and described by Hawkins, Sollas, and others. In Wall-case, No. 13, is a very complete and perfect specimen of *Ichthyosaurus tenuirostris* from the Lower Lias of Street, Somersetshire, presented by Alfred Gillett, Esq. *(see Frontispiece)*.

FIG. 95.—Footprints of *Cheirotherium Barthi* (Kaup, sp.), Bunter sandstone, Hessberg, near Hildburghausen, Germany (reduced).

FOSSIL FISHES.—GALLERY No. 6.

As the varied layers of sandstone, limestone, and clay, which compose the greater part of the superficial crust of the earth, have been accumulated as sedimentary deposits in lakes, estuaries, and seas, one would naturally expect that, of the Vertebrate division of animals, the remains of Fishes would be most frequently met with in these formations; and such is in fact the case, although, from their fragmentary state, it is not always possible to determine their precise systematic position.

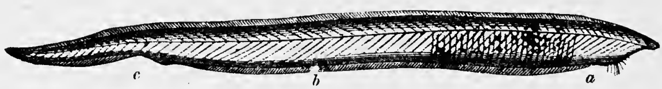


FIG. 96.—The "Lancelet," *Branchiostoma (Amphioxus) lanceolatum* (recent). *a*, mouth; *c*, vent; *b*, abdominal pore.

Some fishes have no hard structures capable of fossilization, and such is likewise the case with most of the lower notochordal forms—the "Sea-squirts" and the "Lancelets"—which seem to connect the Vertebrata with the subkingdoms of Invertebrata. The little "Lancelet" (*Branchiostoma*), for example, has only a membrano-cartilaginous skeleton without vertebræ, ribs, or jaws (Fig. 96); while the ordinary Tunicates, or "Sea-squirts," are equally destitute of any but the most perishable tissues.

Marsipobranchii.

The modern lampreys and hag-fishes also possess no hard structures capable of fossilization, beyond the minute horny teeth (Figs. 97, 98). Technically speaking, in fact, they are not

FIG. 97.

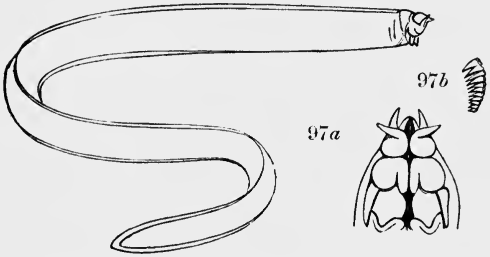


FIG. 98.

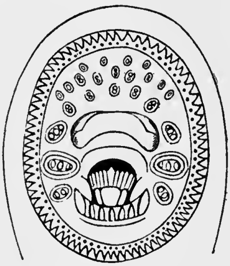


FIG. 97.—The "Hag-fish," *Myxine australis* (recent). 97*a*, Lower aspect of head. 97*b*, A single detached tooth of *Myxine*.
FIG. 98.—Mouth of Lamprey, *Petromyzon fluviatilis*, showing circular arrangement of teeth.

Fishes (*Pisces*), being destitute both of a lower jaw and paired fins. There is now, however, reason to believe that these animals are the degenerate descendants of a class which once possessed not only a hard internal skeleton, but also dermal armour of a very varied kind. The small *Palæospondylus Gunni* (Fig. 99), for example, from the Lower Old Red Sandstone of Caithness. **Table-case No. A.**

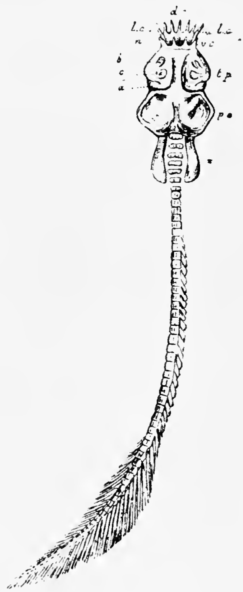


Fig. 99.—*Palæospondylus Gunni*, Traq. Old Red Sandstone; Caithness.

has a skeleton in all essential respects like that of a lamprey, but well-calcified, and with ring-vertebræ. The little tooth-like bodies (Fig. 100), named "Conodonts" by Pander, have also been

Fig. 100.—"Conodonts" from the Cambrian (after Dr. G. J. Hinde). × 10 times.

compared with the denticles of lampreys and hag-fishes; but instead of being chitinous or horny, they consist of phosphate of lime, and thus cannot be satisfactorily determined. These fossils are exclusively Palæozoic, and were first discovered in the Cambro-Silurian and Devonian formations of Russia and North America.

Ostracodermi.

Table-cases, Nos. A, B, and Wall-case, No. 4.

The armoured notochordal animals which possessed neither lower jaw nor paired fins, and are hence now supposed to be related to the lampreys, are found only in Upper Silurian and Devonian rocks. They were for a long time erroneously classified with *Coccosteus* and its allies (see p. 96) under the name of "Placodermata" (plate-skinned animals), but are now distinctly separated from the latter and grouped under the name of OSTRACODERMI (shell-skinned) or OSTRACOPHORI (shell-bearers). The head and anterior portion of trunk are covered with plates; while there are remains of median fins, and often also scales, in the caudal region. No traces of the internal skeleton have been found, and the notochord must have been persistent.

There are three groups of Ostracoderms distinguished by the structure and arrangement of the anterior shield. Firstly, there are the *Heterostraci* (anomalous-shells), comparatively simple, of which the plates exhibit no bone-cells in their tissue and comprise three superposed layers—an inner "nacreous" layer of lamellæ, a relatively thick middle zone of polygonal chambers, and an outer hard layer of vascular dentine. Secondly, the *Osteostraci* (bony-shells), also with simple shields, which exhibit bone-cells in part at least of their tissue. Thirdly, the *Antiarcha*, of which the shields comprise many symmetrically disposed plates, are provided with a pair of lateral appendages, and likewise exhibit bone-cells in their tissue.

The earliest known fish-like shield belongs to *Cyathaspis*, a member of the Heterostraci. One specimen has been recorded from the Wenlock Limestone of the Island of Gothland in the Baltic Sea, and a ventral shield (originally named *Scaphaspis ludensis*) has been found in the Lower Ludlow of Leintwardine, Shropshire. *Cyathaspis Banksi* occurs in the Upper Ludlow "Bone-bed" and Downton Sandstone. The typical Heterostracan genus, *Pteraspis* (Figs. 101, 102), has a dorsal shield composed of seven pieces:—a rostrum, a large median disc, a

Table-case, No. A.

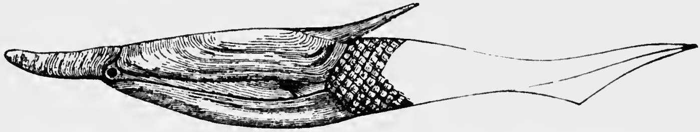


FIG. 101.—Restoration of *Pteraspis rostrata*, Ag.—Lower Old Red Sandstone; Herefordshire.

posterior median spine, an anterior lateral pair of plates pierced by the eyes, and a posterior lateral pair pierced by openings from the gill-chamber. There is a single ventral shield, and the tail in *Pteraspis* is also proved to have been scaly. All the Heterostracan shields are ornamented externally with very fine

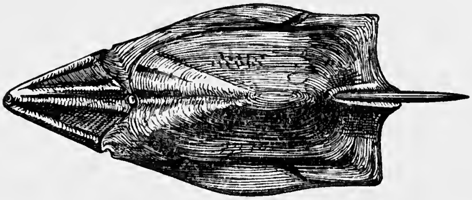


FIG. 102.—Restoration of shield of *Pteraspis rostrata*, Ag., upper aspect (after Lankester).—Lower Old Red Sandstone; Herefordshire.

concentric lines of vascular dentine. They are typically Lower Devonian, and the largest specimens scarcely ever exceed six inches in length.

So far as known, the *Osteostraci* are almost confined to the Uppermost Silurian and the Lower Devonian rocks, only one specimen having been found in the Upper Devonian (Canada). The typical genus is *Cephalaspis* (Fig. 103), represented in the Collection by the finest known specimens from Forfarshire and Herefordshire. Special attention may be directed to the unique group of *Cephalaspis Murchisoni* from the Lower Old Red Sandstone Passage Beds of Ledbury, Herefordshire, presented by George H. Piper, Esq., F.G.S. The head-shield is rounded or tapering in front, truncated behind, and the eyes appear close together in the middle; its outer tuberculated layer is usually

Table-cases, Nos. A, B.

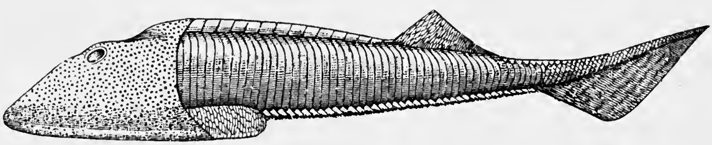


FIG. 103.—*Cephalaspis Murchisoni*, Egert.; L. Old Red Sandstone (Passage Beds), Ledbury, Herefordshire.

removed, and then the middle layer is exposed with its coarse network of blood-vessels. A pair of small flippers at the back of the shield are probably not fins, but connected with the aëration of the gills. The body is covered with rings of bony scutes; there is one dorsal fin; and the tail is distinctly heterocercal. In *Auchenaspis* and *Didymaspis* some of the body-rings are fused together immediately behind the head-shield. *Tremataspis* is a remarkable allied genus.

Wall-case, No. 4, and Table-case, No. B.

Pterichthys (Fig. 104) and *Bothriolepis* are the best-known members of the Antiarcha, which are exclusively Devonian.

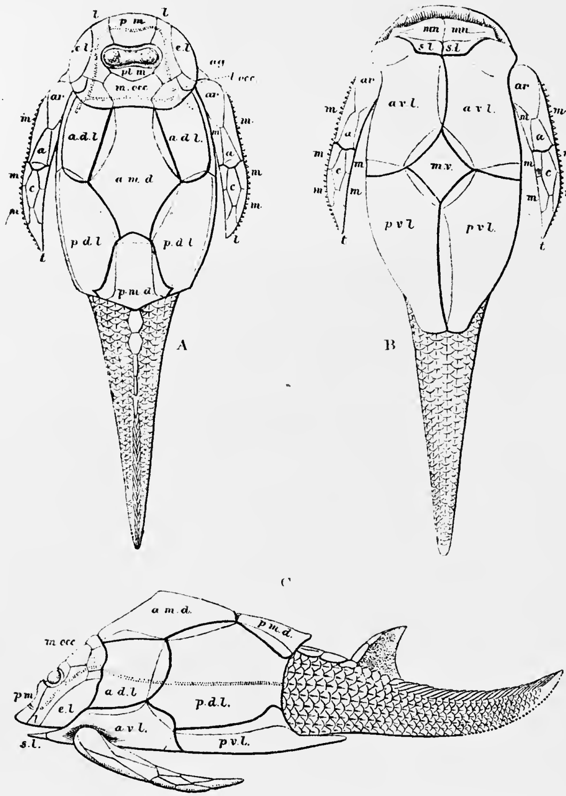


Fig. 104.—*Pterichthys testudinarius*, Ag.; restored by Dr. R. H. Traquair, from the dorsal aspect (A), ventral aspect (B), and lateral aspect (C). In the last figure the caudal fin is omitted. The double dotted lines indicate the grooves of the sensory canal system; and in the trunk, the thick lines represent the exposed borders of the plate, the thin line showing the extent of the overlap. *a.*, anconeal; *a.d.l.*, anterior dorso-lateral; *a.m.d.*, anterior median dorsal; *a.v.l.*, anterior ventro-lateral; *ag.*, angular; *ar.*, articular; *c.*, central; *e.l.*, extra-lateral (or operculum); *l.*, lateral; *l.occ.*, lateral occipital; *m.*, marginal; *m.occ.*, median occipital; *m.v.*, median ventral; *mn.*, mental; *pm.*, premedian; *p.d.l.*, posterior dorso-lateral; *p.m.d.*, posterior median dorsal; *p.v.l.*, posterior ventro-lateral. *pt.m.*, post-median; *s.l.*, semilunar; *t.*, terminal. Lower Old Red Sandstone, Scotland.

These are particularly noteworthy for the pair of jointed appendages fixed to the antero-lateral angles of the body-armour. *Pterichthys* has a scaly hinder region, a dorsal fin, and a heterocercal tail, and is represented by a beautiful series of specimens from the Lower Old Red Sandstone of Scotland. The finest examples of *Bothriolepis* were obtained from the Upper Devonian of Scaumenac Bay, P.Q., Canada, but its tail has never been found, being probably scaleless. *Asterolepis* is an allied genus.

Class 5.—PISCES.

The true fishes all possess a lower jaw and complete or rudimentary paired fins. They are most commonly divided into the subclasses or orders of Elasmobranchii (sharks, rays, and chimæras), Dipnoi (mud-fishes), Ganoidei (enamelled-scaled fishes), and Teleostei (bony fishes). This arrangement, however, was originally based chiefly on a study of the fishes now existing; and more recent investigations among extinct fishes have shown that it cannot be maintained. The limits of these groups are indicated by the brackets to the right of the table on the next page, which explains the system of classification adopted in the Collection.

In tracing the fishes through the successive ages of the past, it is interesting to note the close correspondence between the history of the race and the history of an individual modern Teleostean, at least in one point—the structure of the tail. All the older members of the class either had the extremity of the body straight and tapering, with the fin equally developed above and below (Fig. 105), or there was a slight upward bend of the verte-

FORMS OF TAILS OF FISHES.

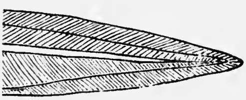


Fig. 105.—Diphycercal. Primitive form.

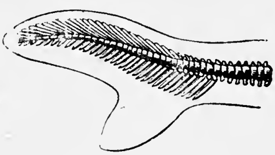


Fig. 106.—Heterocercal. Ancient Form.

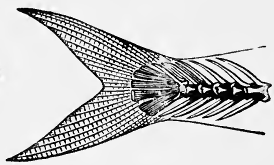


Fig. 107.—Homocercal. Modern form.

bral column, with the lower lobe of the tail-fin much larger than the upper (Fig. 106). In later fishes, the upturned end of the body in the unequally-lobed tail has become more and more abbreviated, and the rays of the fin have gradually become so disposed that to all external appearance the tail has assumed perfect symmetry (Fig. 107). Such changes are precisely repeated in the embryonic history of a living Teleostean, in which the tail is first pointed, then upturned, and then externally symmetrical.

Classification of Fishes.

Sub-class I.—ELASMOBRANCHII. Jaw-apparatus suspended from skull; no operculum; dermal armour without bone-tissue .. .. .. Order I.—Proselachii. Paired fins supported by parallel rods of cartilage; no claspers in male .. .. Order II.—Ichthyotomi. Pectoral fins supported by cartilages radiating from central axis; claspers in male .. .. Order III.—Acanthodii. All fins except caudal with spine in front, and cartilages very short; no claspers .. .. .. Order IV.—Selachii. Pectoral fins with two or three basal cartilages and no central axis; claspers in male .. .. .. Sub-orders. *Tectospondyli* and *Asterospondyli* Sub-class II.—HOLOCEPHALI. Jaw-apparatus fused with skull; an opercular membrane; dermal armour without bone-tissue .. .. .. Order I.—Chimæroidei. Fins as in Selachii ..	Elasmobranchii or Chondropterygii.
Sub-class III.—DIPNOI. Jaw-apparatus fused with skull; an opercular bone; dermal armour often with bone-tissue .. .. Order I.—Sirenoidei. Scaly fishes with paddle-shaped paired fins, these supported by a segmented axis	Dipnoi.
Order II.—Arthrodira. Armoured fishes, the head-shield hinged on body-shield; paired fins rudimentary .. .. Sub-class IV.—TELEOSTOMI. Jaw-apparatus suspended from skull; an opercular bone; dermal armour often with bone-tissue .. .. .. Order I.—Crossopterygii. Paired fins paddle-shaped and fringed with fin-rays .. . Sub-orders. *Haplistia*, *Rhipidistia*, *Actinistia*, and *Cladistia* .. .. .. Order II.—Actinopterygii. Supports of paired fins much shortened and dermal rays chiefly supporting membrane .. .. Sub-orders.—*Chondrostei*, *Protospondyli*, *Aetheospondyli*, *Isospondyli* (in part)	Ganoidei.
Isospondyli (continued), *Plectospondyli*, *Nematognathi*, *Haplomi*, *Apodes*, *Anacanthini*, *Percesoces*, *Pharyngognathi*, *Percomorphi*, *Lophobranchii*, *Hemibranchii*, and *Plectognathi* ..	Teleostei.

Sub-class I.—ELASMOBRANCHII.

Wall-cases, Nos. 1 to 3, and Table-cases, Nos. 25 to 32.

The true fishes begin with the sub-class of Elasmobranchii (laminated or plate-like gills). In these the cranium itself is not divided into any distinct tracts by sutures or ossifications, and the two foremost of the "visceral arches" (cartilaginous rods in the walls of the alimentary tube), which are modified as jaws and hyoid cartilages, have a very slight connection with it. The jaws are mainly suspended by the upper element of the hyoid arch (the "suspensorium") and by a ligament in front; or there is sometimes (*e.g.* in *Cestracion* and *Notidanus*) direct contact either behind or in advance of the eye (see Fig. 118, p. 88). The axial skeleton of the trunk varies from a primitive persistent notochord to a well-calcified vertebral column, composed of distinct centra. The gills are pouch-like, and there are five (six or seven) distinct clefts on each side, which are exposed, having no "gill-cover," or operculum. The body is provided with median and paired fins, the hinder pair being abdominal.

In the majority of the Elasmobranchs, the extremity of the vertebral column is slightly turned upwards, and the lower lobe of the caudal fin is much larger than the upper, producing a "heterocercal" tail. In some, however, like *Squatina* and several of the Rays, the terminal portion of the body is straight, and the fin equally developed above and below, upon the "diphycercal" or "protocercal" plan.

The skin is usually covered more or less closely by numerous small detached plates or granules of dentine, with tubercles or spines (Fig. 108) scattered over the whole surface of the integument, commonly known as "placoid scales." When very small

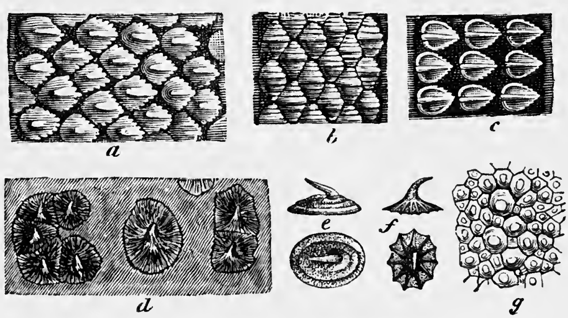


Fig. 108.—Dermal tubercles of Elasmobranch Fishes.
a, shagreen of Dog-fish (*Ginglymostoma*), enlarged; *b*, shagreen of Blue Shark (*Carcharias*), enlarged; *c*, shagreen of Spiny Dog-fish (*Centrophorus*), enlarged; *d*, dermal tubercles of Spiny Shark (*Echinorhinus*), nat. size; *e*, tubercle of Ray; *f*, dermal tubercle of Greenland Shark (*Læmargus borealis*), enlarged; *g*, shagreen of Sting-ray (*Urogymnus*), nat. size.

and close set, as in the Dog-fish, this dermal covering is called "shagreen."

Those of the Elasmobranchs with lateral gill-clefts are commonly known as "Sharks" (Fig. 109), while those with depressed body and ventrally placed gill-clefts fall under the denomination of "Rays" (Fig. 110). There are many intermediate forms, however, which it is impossible to distinguish in a fossil state.

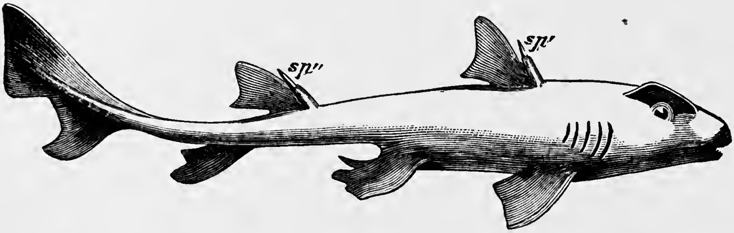


FIG. 109.—Port Jackson Shark, *Cestracion Philippi*, Lacép., from Australia. *sp'*, anterior dorsal spine; *sp''*, posterior dorsal spine.

From the perishable nature of their skeletal parts, it is obvious that the palæontological history of these fishes is most difficult to decipher. In the majority of instances, the fossils consist merely of detached spines, shagreen-granules, teeth, or pieces of cartilage; and it is often impossible to correlate these unsatisfactory fragments, so that the different parts of the same species not unfrequently receive even distinct generic names.

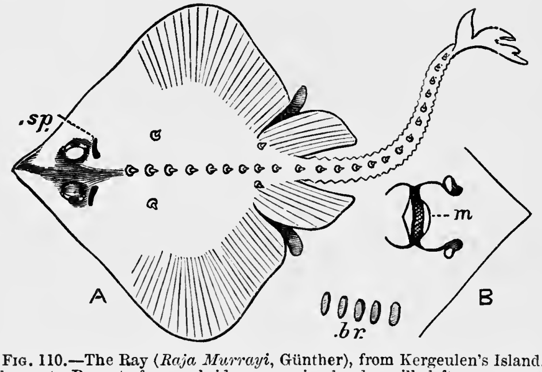


FIG. 110.—The Ray (*Raja Murrayi*, Günther), from Kergeulen's Island. A, dorsal aspect; B, part of ventral side; *sp.*, spiracle; *br.*, gill clefts; *m.*, mouth.

Wall-case, No. 3.

Sometimes, however, complete fishes are met with, and many beautiful examples are shown from the Lias of Lyme Regis, the Lithographic Stone of Bavaria, and the Upper Cretaceous of Mount Lebanon.

The first table-case on the left and the adjoining wall-case are filled with numerous spines and other dermal appendages of cartilaginous fishes, perhaps mostly Elasmobranchs, which cannot yet be precisely determined; they are conveniently grouped together as *Ichthyodorulites* ("fish-spine-stones"). [See Fig. 111.] **Wall-case, No. 1.** **Table-case, No. 25.**

The earliest evidence of the sub-class is placed here, namely, the dorsal fin-spines from the Ludlow Bone-bed (Upper Silurian) and the Old Red Sandstone, bearing the name of *Onchus*. *Ctenacanthus* is founded upon dorsal spines from the Carboniferous. The huge *Oracanthus pustulosus* (*Phoderacanthus*), three feet in length, from the Carboniferous Limestone of Bristol, is the largest ichthyodorulite known; and there are also triangular paired spines of considerable size from the same formation,

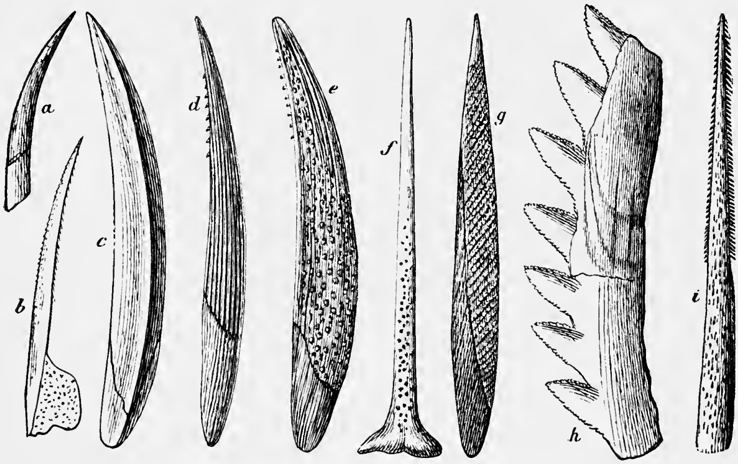


Fig. 111.—Spines of Elasmobranch and Chimæroid Fishes.
a, *Acanthias* (recent); *b*, *Callorhynchus* (recent); *c*, *Machæracanthus* (Devonian); *d*, *Hybodus* (Jurassic); *e*, *Asteracanthus* (Jurassic); *f*, *Squaloraja* (Lias); *g*, *Gyracanthus* (Carboniferous); *h*, *Edestes* (Carboniferous); *i*, *Pleuracanthus* (Carboniferous).

which are named *Oracanthus Milleri*, and provisionally associated with several flat dermal plates having a corresponding ornamentation. Spines of *Edestes* (Fig. 111*h*) occur in the Carboniferous of N. America, Australia, and Russia, and are remarkable for their curvature and the great size of the posterior denticles; the latter are in the form of serrated teeth, and led their first discoverer, Prof. Leidy, to conclude that the fossils were fragments of jaws. *Gyracanthus* (Fig. 111*g*) occurs abundantly in the British Carboniferous, and is represented both by the well-known paired spines (with an ornament of angulated ridges, and ordinarily abraded extremity), triangular dermal bones, and shagreen granules: the teeth probably bear another name. *Acondylacanthus* resembles the spine of a Ray; and *Erismacanthus* and *Lispacanthus* are very suggestive of the rostral spine of male Chimæroids.

These ichthyodorulites show that the earliest Elasmobranchs differed very much from the existing members of the sub-class. The fact is further emphasised by the discovery of several Elasmobranch skeletons of Devonian, Carboniferous, and Permian age, which show that at least three extinct orders are represented.

ORDER I.—**Proselachii.**

The first of these orders is that of the PROSELACHII, represented only by *Cladoselache*, from the Upper Devonian of Ohio, U.S.A. This is a notochordal shark without spines or armour, except a ring of plates round the eye; its paired fins are mere balancers supported by parallel rods of cartilage, and the teeth are identical with the detached Palæozoic teeth provisionally named *Cladodus*. Only fragments are exhibited.

Table-case, No. C.

ORDER II.—**Ichthyotomi.**

The second order, that of the ICHTHYOTOMI, is known by numerous tolerably complete skeletons from the Carboniferous and Lower Permian. Fine examples of the typical genus *Pleuracanthus* (Fig. 112) are exhibited from the Lower Permian of Rhenish Prussia, Silesia, and Bohemia. The isolated spines of *Pleuracanthus* and the teeth known as *Diplodus* from the

Wall-case, No. 3.

Table-case, No. C.

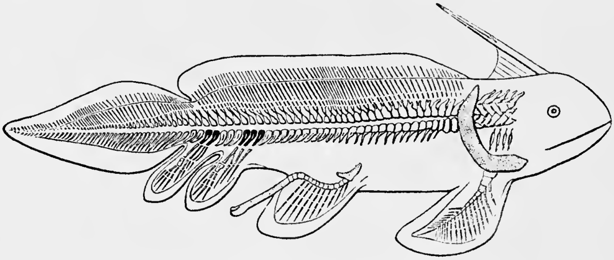


FIG. 112.—*Pleuracanthus Gaudryi*, Brongn. (restoration by C. Brongniart); Coal-measures, Commentry, France.

British Carboniferous, especially Coal-measures, are also placed here. Like the Proselachii, these sharks are notochordal; but they differ in having paddle-shaped paired fins, supported by a more or less branching arrangement of cartilages. The median fins are very extensive, and there is usually a median dorsal spine fixed at the back of the head. There is reason to believe that some of the teeth named *Cladodus* also belong to this order.

ORDER III.—**Acanthodii.**

Wall-case, No. 3, and Table-cases, Nos. D, E.

The ACANTHODII form perhaps the most remarkable extinct order of Elasmobranchs. They are small fishes exclusively confined to Palæozoic rocks, ranging from the Lower Devonian to the Lower Permian. The tail is heterocercal, and each of the fins, except the caudal, is armed in front with a formidable spine, though in itself a mere membrane without cartilage supports beyond the base. The eye is often surrounded by a ring of plates, and the teeth when observable are fused with the border of the jaws. There is no hard operculum, and the trunk is covered with minute, quadrangular, shining scales; the slime-canal of the "lateral line" passes between two series of the latter. *Acanthodes* (Fig. 113), from the Carboniferous of

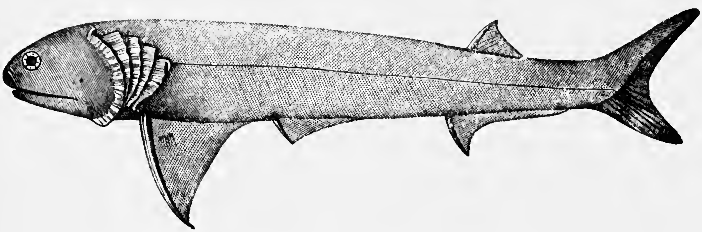


FIG. 113.—*Acanthodes Wardi*, Egert.; Coal-measures, Staffordshire.

Scotland and England, and the Lower Permian of Germany, is the typical genus, and is represented in the cases by numerous nearly complete fishes. The beautifully preserved *Mesacanthus*, from the Lower Old Red Sandstone of Scotland, and the Upper Devonian of Canada, is almost identical. *Climatius*, from the Lower Old Red Sandstone of Scotland, is remarkable for its broad spines, of which three or four pairs are fixed along the body between the pectoral and pelvic fins. *Diplacanthus* and *Parexus*, of corresponding age, are also remarkable.

ORDER IV.—**Selachii.**

The order of SELACHII, or sharks and rays proper, also seems to have been represented in the Palæozoic Era, though there is no conclusive evidence of its existence before the Lias. It is characterised, among other features, by the structure of the paired fins, which are always supported by large cartilages, but never exhibit the branched arrangement seen in *Pleuracanthus*, having either two or three basal pieces. The "Rays" are destitute of an anal fin, and their vertebræ, when fully developed, are strengthened by concentric layers of calcified tissue; they are hence named TECTOSPONDYLI (covered-vertebræ). The "Sharks and Dog-Fishes" always exhibit an anal fin, and when the vertebræ are strengthened, radiating plates predominate over concentric plates; they are thus known as ASTEROSPONDYLI (star-vertebræ). It is impossible as yet to make any satisfactory arrangement of the ancestors of these two sub-orders which are destitute of vertebræ, or have them only incompletely formed.

SUB-ORDER I.—**Tectospondyli.**

Table-case, No. 31. The Spinacidæ, or spiny dog-fishes, of the present day are supposed to be little-modified descendants of the early ancestors of the rays; but they are scarcely known among fossils. Well-preserved fishes which seem to belong to the existing genera *Acanthias* and *Centrophorus*, are exhibited from the Upper Chalk of Mount Lebanon. The Petalodontidæ, of Carboniferous and Permian age, may perhaps be related to the Spinacidæ, but they are only known by fragments, chiefly teeth. *Petalodus* and *Polyrhizodus* are Lower Carboniferous, while *Janassa* is both Carboniferous and Permian. The existing Squatinidæ date back to the Lower Kimmeridgian, fine examples of *Squatina* being known from the Lithographic Stone of Bavaria (Figs. 114, 115). Detached teeth are exhibited from the English Cretaceous, Eocene, and Pliocene Formations. The Pristiophoridæ are insignificant as fossils, and the Pristidæ are represented only by the Cretaceous *Sclerorhynchus* and by fragments of *Pristis*-like "saws" from the Eocene and later deposits. **Wall-case, No. 3.** *Sclerorhynchus atavus* is a remarkable fish from the Upper Chalk of Mount Lebanon, with the "saw" scarcely more developed than that of a *Pristiophorus*. Numerous Rhinobatidæ, apparently identical with the existing *Rhinobatus*, occur well-preserved in the Lithographic Stone of Bavaria and France, and in the Upper Cretaceous of Mount Lebanon. The fine slab of *Rhinobatus* (*Spathobatis*) *bugesiacus* affixed to the wall between Wall-cases Nos. 2 and 3, is particularly worthy of examination. The Rajidæ and Trygonidæ are also represented by numerous fine specimens from the Upper Chalk of Mount Lebanon, there being apparently *Raja* itself and a small extinct sting-ray named *Cyclobatis*. Torpedos **Table-case, No. 32.** occur in the Upper Eocene of Monte Bolca, near Verona, but are not represented in the Collection.

The Carboniferous teeth named *Psammodus* and *Copodus* may belong to a family of devil-fishes, related to the modern Myliobatidæ, but their relationships are very uncertain. They are always found detached, and a large series is exhibited from

Fig. 114.

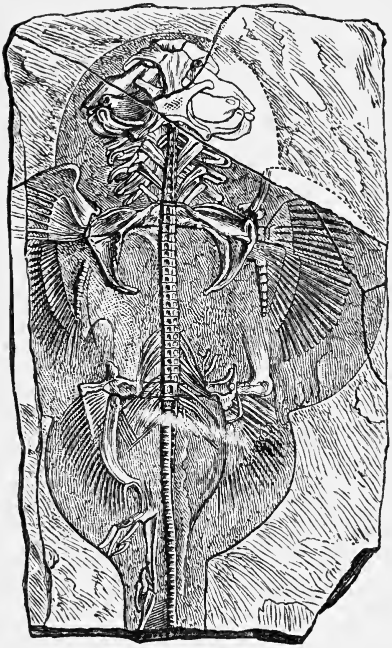


Fig. 115.

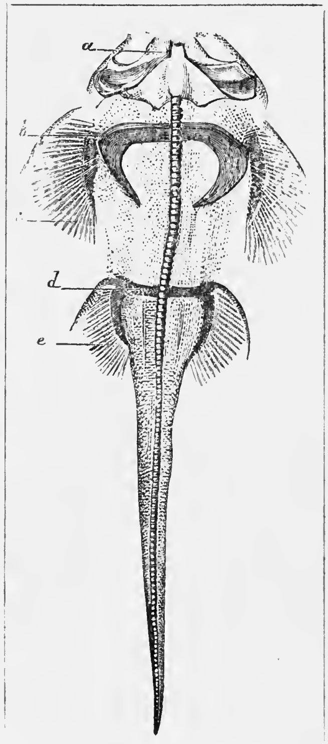


Fig. 114.—*Squatina alifera*, Münst. sp. (after Fraas), Lithographic Stone (Upper Oolite), Bavaria.
Fig. 115.—*Squatina speciosa*, Meyer; Lithographic Stone (Upper Oolite), Bavaria.
a, mandibular cartilage; *b*, pectoral arch; *c*, pectoral fin; *d*, pelvic arch; *e*, pelvic fin.

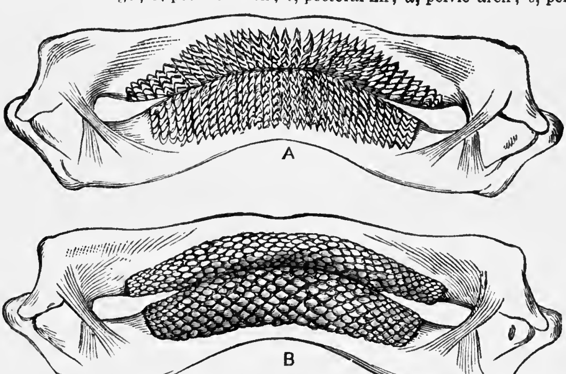


Fig. 116.—Jaws of Male (A) and of female (B) Thornback Skate, *Raja clavata*, showing the remarkable variation in the dentition which they exhibit.

Table-case, No. 32.

the Carboniferous Limestone of Armagh, Ireland. The well-known teeth of *Ptychodus* from the Chalk are proved to belong to a large ray probably of the *Myliobatis* type, by specimens both in this Museum and in the Brighton Museum. The arrangement of the teeth in the jaws is shown in Fig. 117. Typical portions of the dentition of *Myliobatis* occur abundantly in the English Eocenes; and the largest known specimen (*M. Pentoni*) is exhibited from the Lower Tertiary of the Mokattam Hills, Cairo, Egypt. *Aetobatis* and *Rhinoptera* are also Eocene.

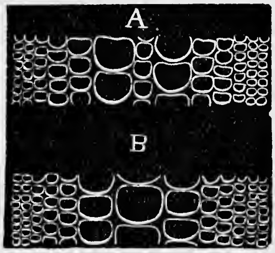


Fig. 117.—Diagram of arrangement of teeth of *Ptychodus decurrens*, Ag.; English Chalk.—A, upper jaw; B, lower jaw.

Sub-order II.—**Asterospondyli.**

Of the Asterospondyli or Sharks, the Notidanidæ are perhaps the most primitive surviving family. They are represented only by five or six species at the present day, and are

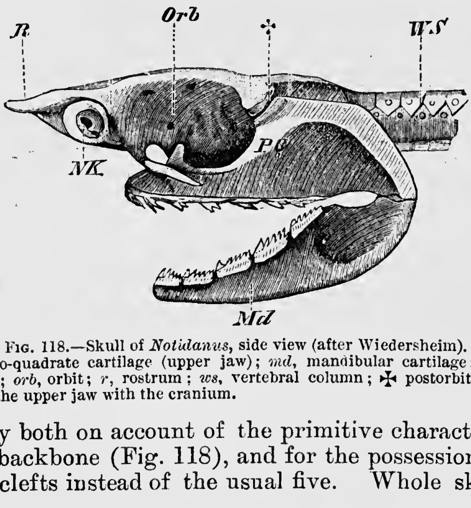


Fig. 118.—Skull of *Notidanus*, side view (after Wiedersheim). *pq*, pterygo-quadrate cartilage (upper jaw); *md*, mandibular cartilage; *nk*, nasal capsule; *orb*, orbit; *r*, rostrum; *ws*, vertebral column; ✠ postorbital articulation of the upper jaw with the cranium.

noteworthy both on account of the primitive character of their skull and backbone (Fig. 118), and for the possession of six or seven gill-clefts instead of the usual five. Whole skeletons of

Notidanus are known from the Lithographic Stone of Bavaria and the Upper Cretaceous of Mount Lebanon, but there are none in the Collection. Numerous teeth are shown from Jurassic, Cretaceous, and Tertiary Formations, and it is noteworthy that the largest and most complex teeth are those of the latest deposits (Fig. 119). The Cestraciontidæ are also primi- **Table-case, No. 27.**

FIG. 119.—Teeth of *Notidanus gigas*, Sism.; Red Crag, Suffolk.

tive and represented only at the present day by the Port Jackson Shark (*Cestracion*, Fig. 109, p. 82). Their extinct representatives are extremely numerous. As in *Cestracion* (Fig. 120), the majority of the teeth are always adapted for crushing, though

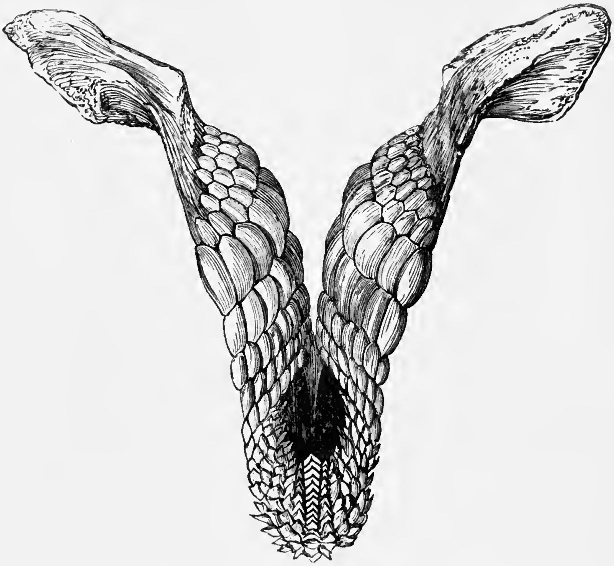


FIG. 120.—Jaw of Port Jackson Shark, *Cestracion Philippi* (recent).

some in front are prehensile and many are cuspidate. Their variation in different parts of the mouth is thus so great, that it is often almost impossible to name detached fossil teeth. As in *Cestracion*, also, each of the two dorsal fins is invariably pro-

Table-case, No. 27.

vided with an anterior spine. The Carboniferous sharks, *Sphenacanthus* and *Tristychius*, with cuspidate teeth and ribbed dorsal fin-spines, are probably to be placed here; so also are the fine teeth from the Carboniferous Limestone named *Orodus*. *Hybodus*, ranging from the Muschelkalk to the Wealden, has a persistent notochord, cuspidate teeth, and ribbed dorsal fin-spines (Fig. 123); many specimens, presumably males, are

Fig. 121.

Fig. 122.

Fig. 123.

Fig. 121.—A, spine of *Lepracanthus Colei*, Owen; Coal-measures, Ruabon, N. Wales; B, a portion of the spine enlarged, to show the external ornamentation.
Fig. 122.—Teeth of *Acrodus Anningiæ*, Ag.; Lower Lias, Lyme Regis.
Fig. 123.—Dorsal spine of *Hybodus*; Wealden, Sussex.

further provided on either side of the head with two large barbed hooklets, each fixed on a broad base, and these were originally named *Sphenonchus* by Agassiz, who supposed them to be the teeth of a distinct fish. The skull much resembles that of *Notidanus*, and the teeth in some species are also very similar to the early forms of the last-named genus. The finest specimens of *Hybodus* exhibited, were obtained from the Lower Lias

Wall-case, No. 2, and

of Lyme Regis and the Wealden of Pevensey Bay, Sussex. *Palæospinax*, from the Lower Lias of Lyme Regis, and the Upper Lias of Würtemberg, is a small fish with smooth dorsal fin-spines and simple constricted vertebræ; *Synechodus*, of Cretaceous age, is almost identical. *Acrodus*, ranging from the Muschelkalk to the Gault, only differs from *Hybodus* in the less cuspidate character of its teeth (Fig. 122). *Asteracanthus*, with a dentition commonly named *Strophodus* (Fig. 124), is proved by specimens in the collection to differ only from *Acrodus* in the pattern on its teeth and fin-spines. Fine examples of its head-spines (*Sphenonchus*), from the Oxford Clay of Peterborough, are exhibited; while a jaw in a block of Great Oolite from Caen, Normandy (Fig. 124), is unique. It will be observed that the front prehensile teeth in *Hybodus*, *Acrodus*, and *Asteracanthus* (*Strophodus*), are relatively larger and less numerous than those

Table-cases, Nos. 27, 28.

Table-case, No. 29.

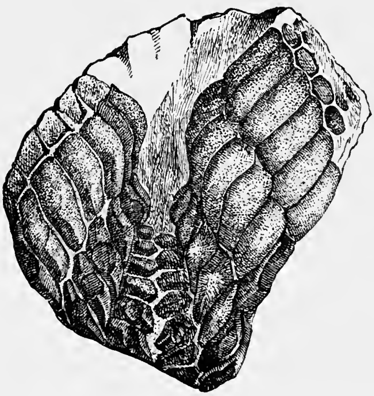


FIG. 124.—Jaw of *Asteracanthus* (*Strophodus medius*, Owen); Great Oolite, Caen, Normandy.

of *Cestracion*. The latter genus seems to range from the Upper Jurassic to the present day.

An interesting Carboniferous family of which little is known beyond the dentition, is that of the Cochliodontidæ, apparently closely related to the Cestracionts. Their jaw is arranged somewhat like that of *Cestracion*, but the several series of lateral teeth are each represented by a single plate, coiling inwards by growth at the outer edge. *Cochliodus* (Fig. 125) is the typical genus, and *Streblodus*, *Psephodus*, *Sandalodus*, *Pœcilodus*, etc., are very similar forms. Many of the teeth named *Helodus* pertain to the symphysis of the jaw of these fishes; and in one genus, *Pleuroplax*, from the Lower Carboniferous and Coal Measures, such teeth are only imperfectly fused together in the plates.

Table-case, No. 30.

Wall-case, No. 3, and Table-case, No. 27.

The Scylliidæ range from the later Jurassic upwards. They are represented in the Bavarian Lithographic Stone by *Palæoscyllium*, in the Upper Chalk of Mount Lebanon by

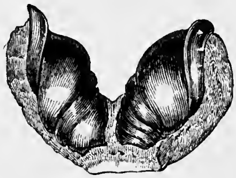


FIG. 125.—Teeth of *Cochliodus contortus*, Ag.; Carboniferous Limestone, Armagh.

Mesiteia, and in the English Chalk by *Cantioscyllium*. Teeth of the existing *Ginglymostoma* are exhibited from the Eocene.

Wall-case, No. 3, and Table-cases, Nos 26 and 27.

The Lamnidæ and Carchariidæ are the characteristic sharks of modern times, but are very rarely found fossil except in the form of detached teeth, vertebræ, and portions of calcified cartilage. To the Lamnidæ may be assigned the fine examples of *Scapanorhynchus* from the Upper Cretaceous of Mount Lebanon, which exhibit a dentition identical with that of *Odontaspis*, but differ in the remarkable elongation of the snout and in the arrangement of the fins. To the Carchariidæ belong several fine fishes from the Upper Eocene of Monte Bolca, near Verona, of which there are no specimens in the Collection. A large series of detached teeth is exhibited, but it is impossible to name and arrange them satisfactorily, owing to the variation of shape always occurring in one and the same mouth. *Lamna* (including *Otodus*, in part) and *Oxyrhina* seem to range from the Cretaceous,

FIG. 126.

FIG. 126.—Tooth of *Odontaspis elegans*, Agassiz; London Clay.

FIG. 127.

FIG. 127.—Tooth of *Carcharodon megalodon*, Agassiz; Suffolk Crag. (One-third nat. size.)

while *Corax* is the tooth of an extinct member of the Lamnidæ of the same age. *Odontaspis* (Fig. 126) is Tertiary and Recent. The Jurassic *Orthacodus* may even belong to this family. The teeth of *Carcharodon*, however, are the most interesting of such fossils, those named *Carcharodon megalodon* (Fig. 127) having an almost world-wide distribution. Specimens are exhibited from New Zealand, Australia, South Carolina, the West Indies, France, Spain, Italy, Malta, and Arabia, as also from the Antwerp and Suffolk Crags. The Carchariidæ are almost, if not exclusively, Tertiary, and only a small collection of teeth of *Galeocerdo*, *Carcharias*, *Hemipristis*, etc., is exhibited.

It may be interesting to add that in some places, both in the Atlantic and Pacific (especially at extreme depths in the red-clay areas), the "Challenger" dredged up many teeth of Sharks and ear-bones of Whales, all in a semi-fossil state, and usually impregnated with oxides of iron and manganese. The Sharks' teeth belong principally to species believed to be extinct, and resemble those found fossil in the late Tertiary formations.

Sub-class II.—HOLOCEPHALI.

Order I.—Chimæroidei.

Wall-case. No. 3, and Table-case, No. 33.

The Chimæras resemble the Sharks in many important features, but, in the skull, the upper jaw is fused with the cranial cartilage, not suspended by the upper part of the hyoid arch. The skeleton is wholly cartilaginous, and the notochord is tolerably persistent, the vertebræ being represented by mere slender rings. In the two living genera, there is a strong spine in front of the dorsal fin: the gill-clefts are covered by a fold of skin, so that only a single external opening is observed: and the dentition consists of four plates above and two below.

Teeth of *Rhynchodus* and *Palæomylus* from the Devonian of North America, and of *Ptyctodus* from the Devonian of Russia, are the earliest fossils hitherto definitely referred to this sub-class, but there are no examples in the Collection. The early Jurassic family of Squaloraiidæ is represented by the unique genus *Squaloraja*, of which several fine specimens are exhibited from the Lower Lias of Lyme Regis. The trunk is shaped like that of a narrow skate of the family Rhinobatidæ, and the rostral spine in the male is long and slender; there is no dorsal fin-spine. Another Jurassic family is that of the Myriacanthidæ. *Myriacanthus* itself, also from the Lower Lias of Lyme Regis, is represented by numerous fragmentary specimens. One slab of *M. granulatus* shows the dorsal and rostral spines, and a produced snout resembling that of the existing *Callorhynchus*. The dentition (originally named *Prognathodus*) is remarkable for a median chisel-like tooth in front of the lower jaw. The long dorsal spine is covered with tubercles, which are often pointed and thorn-shaped. The still-surviving family of Chimæridæ is first represented by teeth of *Ganodus* and

Ischyodus in the Stonesfield Slate, and the latter genus ranges upwards to the Upper Cretaceous. Nearly complete skeletons have been found in the Lithographic Stone of Bavaria. *Eda-*

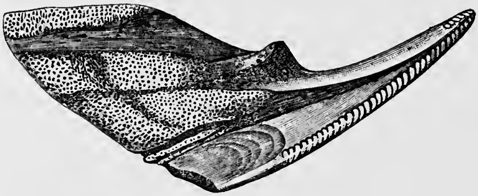


FIG. 128.—Lower Jaw of *Edaphodon leptognathus*, Ag.; Middle Eocene, Bracklesham Bay, Sussex.

phodon (Fig. 128) and *Elasmodus* are Cretaceous and Eocene; *Chimæra* dates back at least to the Pliocene.

Sub-class III.—DIPNOI.

ORDER I.—Sirenoidei.

Wall-case, No. 5, and Table-case, 34.

The typical Dipnoi (double-breathers) are so named because in their living representatives the air-bladder assumes the function of a lung, and thus furnishes them with a second

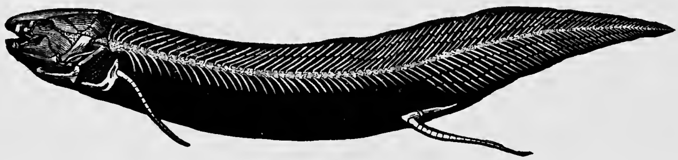


FIG. 129.—Skeleton of the African Mudfish, *Protopterus annectens*, living in the Rivers of Africa.

means of respiration. They are a nearly extinct race, only three forms now surviving, namely, *Protopterus* in Africa (Fig. 129), *Lepidosiren* in South America, and *Ceratodus* (*Epiceratodus*) in Australia (Fig. 130).

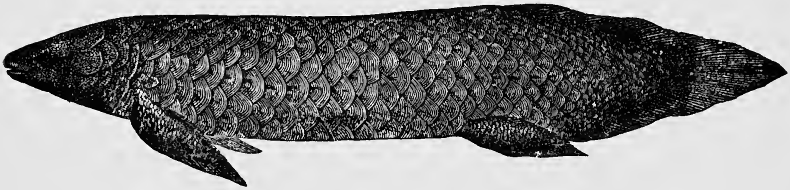


FIG. 130.—"The Australian Mudfish," *Ceratodus Forsteri* (recent), Australia.

The notochord in these fishes is always persistent, and the tail is diphycercal or heterocercal. There are two pairs of nostrils more or less within the mouth (Fig. 131, *n*); and the dentition (Fig. 131) consists of a pair of ridged plates above and below, usually with a pair of incisor-like vomerine teeth above. An ordinary bony operculum covers the gill-cavity. The paired fins are acutely lobate, supported by a central jointed cartilaginous stem fringed with radial cartilages and dermal fin-rays.

The earliest Dipnoi are Lower Devonian. *Dipterus* (Fig. 132) is beautifully preserved in the Caithness flagstones, and exhibits two dorsal fins, a heterocercal tail, and enamelled scales. *Phaneropleuron* (Fig. 133) occurs in the Upper Old Red Sandstone of Dura Den, Fifeshire, and *Scaumenacia* in the Upper Devonian of Canada. *Ctenodus* is characteristic of the Carboniferous and Lower Permian, and is met with both in Europe and America. All these genera are characterized by the roof of the skull exhibiting more numerous bones than that of the living Dipnoi. The teeth of *Ceratodus* occur in early Mesozoic strata in Europe, India, South Africa, and Central North America; but only one important skull has

Wall-case, No. 5, and Table-case, No. 34.

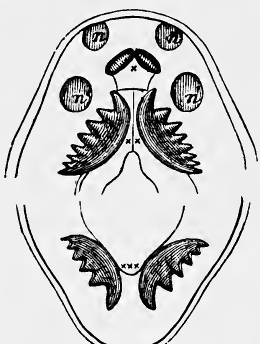


Fig. 131.—Mouth of *Ceratodus*. *nn*, narial openings; *x*, vomerine teeth; *xx*, palato-pterygoid teeth; *xxx*, mandibular teeth.

been described, this from the Rhætic of Austria. A fine series of teeth is exhibited from the Rhætic of Aust Cliff near

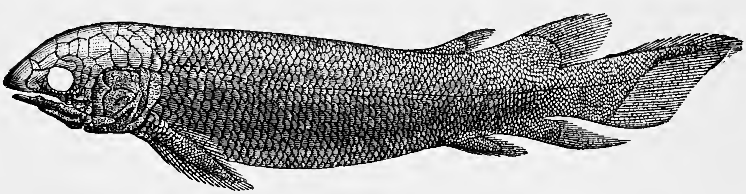


Fig. 132.—*Dipterus Valenciennesi*, Sedgw. and Murch. (restored by C. H. Pander); Lower Old Red Sandstone, Scotland.

Bristol, and from the Trias (Lettenkohle) of Würtemberg. The characters of the skull of *Ceratodus* in the Museum of the

FIG. 133.—*Phaneropleuron Andersoni*, Huxl. (restored by Dr. R. H. Traquair); Upper Old Red Sandstone, Dura Den, Fife.

Austrian Geological Survey, Vienna, suggest that the early Mesozoic fish was generically distinct from the living fish similarly named from the Queensland rivers.

ORDER II.—**Arthrodira.**

Wall-case, No. 4.

The *Coccosteus*-like fishes have already been mentioned (p. 76) as originally classified with the Ostracoderms in the un-natural and artificial group of "Placodermata." In them the head and anterior portion of the trunk are armoured with bony plates, and the head is movable with respect to the trunk. In all the satisfactorily-known genera, there is an elaborately-formed joint between the hinder angles of the head-shield and a rounded process of the antero-lateral plates of the trunk; an arrangement unique among fishes and referred to in the name ARTHRODIRA (joint-neck) now given to this group. The principal upper teeth are fixed on the bones of the roof of the mouth; the lower jaw comprises only one bone on each side. The notochord must have been persistent, and the paired fins are rudimentary or absent.

The Arthrodira are only provisionally placed among the Dipnoi, on account of the very striking resemblance between their dentition and that of certain mud-fishes, also because they *seem* to have possessed a skull of the same type.

Coccosteus (Fig. 134) is the best-known Arthrodiran, and a fine series of specimens is exhibited from the Lower Old Red Sandstone of Scotland. There is also a unique head-shield from the Upper Devonian of Scaumenac Bay, P.Q., Canada. The eyes form notches in the head-shield; there seem to be premaxillæ, and there is one large plate upon the cheek which may be maxilla or suborbital, or both. The teeth are stout and conical, in one close series on the mandible, clustered on the palate. A pair of dermal plates occupies the position of clavicles; and the basal supports of the pelvic fins are often distinct (Fig. 134). There is a membranous median dorsal fin, and the tail may have been either diphycercal or heterocercal.

Homosteus (Hugh Miller's "Asterolepis of Stromness") is a very similar fish, with toothless jaws and the eyes within the head-shield. Plaster casts of the shields of *Homosteus Milleri*

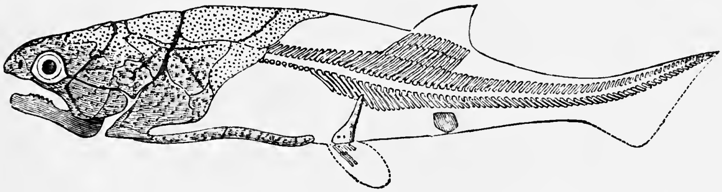


FIG. 134.—*Coccosteus decipiens*, Ag.; Lower Old Red Sandstone, Scotland.

from the Caithness flagstones are exhibited on the pillar between Wall-cases Nos. 4 and 5. There are fragments of other species from the Devonian of Livonia, Russia. *Heterosteus* is a gigantic fish from the Devonian of Livonia, with a great bony process from the body-shield extending forwards on each side of the head.

Wall-case, No. 4.

Dinichthys is a still larger Arthrodiran from the Upper Devonian of Ohio, U.S.A. Its dentition (Fig. 135) much resembles that of the recent *Protopterus*.

FIG. 135.—Jaws of *Dinichthys*; Devonian, North America.

Sub-class IV.—TELEOSTOMI.

These are fishes with a bony armour or bony skeleton, or both; with the margin of the mouth completed by membrane-bones; with the more or less ossified cartilages of the upper jaw suspended from the skull by the upper part of the hyoid arch (hyomandibular); and with a bony operculum covering the gill-cavity. The name of the sub-class Teleostomi (complete-mouth) refers to the ossification of the margin of the jaws.

Nearly all the Devonian representatives of this sub-class have lobate paired fins fringed with dermal rays, and are thus named CROSSOPTERYGII (fringe-fins). A single Devonian genus, *Cheirolepis*, belongs to a higher order which began to replace the Crossopterygians in the Carboniferous period, and which is named ACTINOPTERYGII (ray-fins) because here the lobe is insignificant and the enlarged dermal rays support almost or quite the whole of each paired fin.

Order I.—**Crossopterygii.**

Wall-cases, Nos. 5 to 7, and Table-case, No. 35.

The fringe-finned fishes, or Crossopterygians, are now almost extinct, being represented only at the present day by *Polypterus* (Fig. 136) and *Calamoichthys* of the African rivers. In the Devonian and Carboniferous periods they existed in

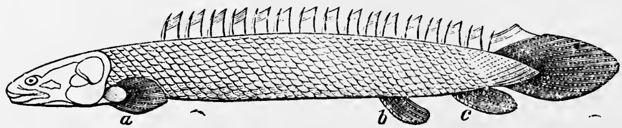


Fig. 136.—*Polypterus bichir*, living in the Nile, Gambia, etc. *a*, pectoral fin; *b*, pelvic fin; *c*, anal fin.

large numbers and in much greater variety. *Holoptychius* (Fig. 137) is an Upper Devonian genus from Scotland and Russia, with long and acutely-lobate pectoral fins, obtusely-lobate pelvic

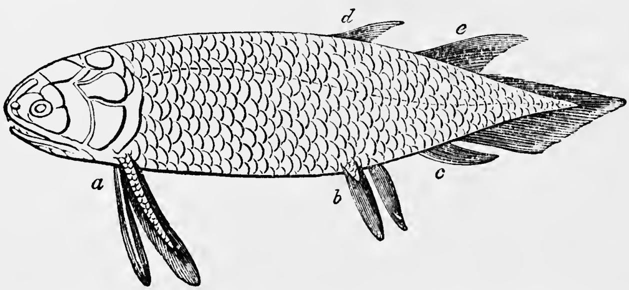


Fig. 137.—*Holoptychius;* U. Old Red Sandstone, Fifeshire (restored by Huxley). *a*, paired pectoral fins; *b*, pelvic fins; *c*, the anal fin; *d*, anterior dorsal fin; *e*, posterior dorsal fin.

fins, and thick, round, deeply overlapping scales. *Glyptolepis*, from the Lower Old Red Sandstone of Scotland, and apparently from the Upper Devonian of Canada, is a nearly identical genus. *Glyptolæmus* (Fig. 138), from the Upper Old Red Sandstone of Dura Den, Fifeshire, has more obtuse pectoral fins and rhombic scales. *Osteolepis* (Fig. 139), *Diplopterus*, *Thursius* (Devonian), and *Megalichthys* (Carboniferous and Lower Permian) are another group of genera with enamelled rhombic

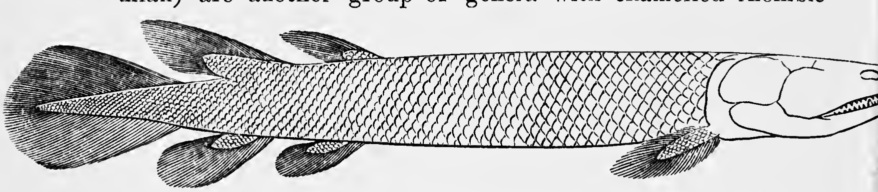


Fig. 138.—*Glyptolæmus Kinnairdi*, Huxl. (restored by Huxley); U. Old Red Sandstone, Scotland.

scales and obtusely-lobate paired fins. *Rhizodopsis* is represented by small species in the Carboniferous, *Rhizodus* and *Strepsodus* by comparatively large species. A fine series of remains of *Rhizodus Hibberti* and *R. ornatus*, from the Lower Carboniferous of Scotland, is exhibited in Wall-case No. 6. **Wall-case No. 6.**

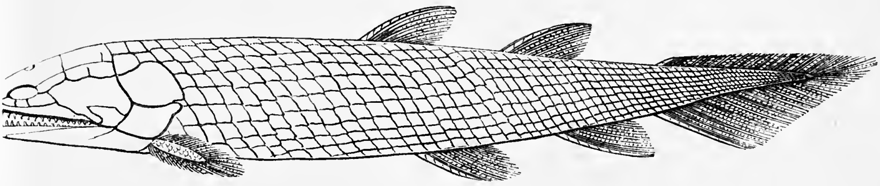


Fig. 139.—*Osteolepis macrolepidotus*, Ag. (restored by C. H. Pander); L. Old Red sandstone, Scotland.

The Cœlacanthidæ (hollow-spines) are the most remarkable Crossopterygians, ranging almost unchanged from the Lower Devonian to the Upper Chalk. Their name refers to the circumstance that the spines of the backbone are only superficially ossified and so appear hollow when fossilized. The head-bones and opercular bones are much reduced, and the tail is produced into a small terminal extension. The air-bladder is ossified. The trunk is covered with thin, deeply overlapping scales. **Wall-case, No. 7, and Table-case, No. 35.**

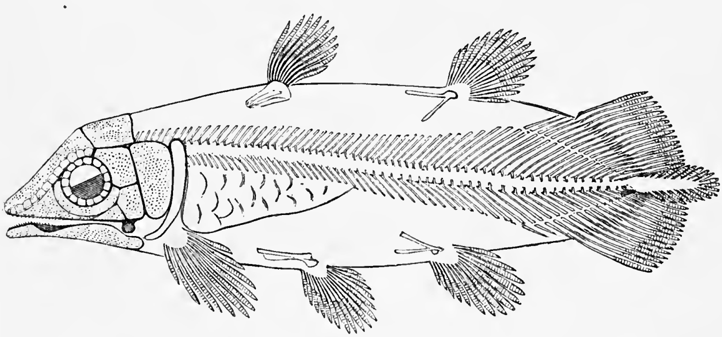


Fig. 140.—*Undina (Holophagus) gulo*, Egert.; Lower Lias, Lyme Regis.

Cœlacanthus is Carboniferous and Permian; *Undina* (Fig. 140) is Jurassic, and beautiful specimens are exhibited from the Lower Lias of Lyme Regis; *Macropoma* is Cretaceous, and represented by the unique collection of Dr. Mantell besides later acquisitions from the English Chalk.

ORDER II.—**Actinopterygii.**

SUB-ORDER I.—**Chondrostei.**

Wall-case, No. 8, and Table-cases, Nos. 37 to 39.

The earliest known ray-finned fishes are the Palæoniscidæ, represented in the Devonian by *Cheirolepis.* They exhibit a very imperfectly ossified skeleton with heterocercal tail; and they must have had a persistent notochord. In their most fundamental characters they agree with the modern sturgeons, and are thus classed in the same sub-order (Chondrostei).

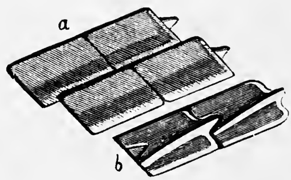


FIG. 141.—Ganoid scales of *Elonichthys striatus*, Ag. sp.; Carboniferous.

Nearly all of them, however, are covered with regular series of scales, which are usually rhombic and united by a peg-and-socket articulation (Fig. 141). *Elonichthys*, *Rhadinichthys*, and *Gonatodus* are the commonest Carboniferous genera; *Palæoniscus* (Fig. 142), *Acrolepis*, *Amblypterus*, and *Pygopterus* are Permian; *Gyrolepis* is Triassic, and *Atherstonia* is represented by a fine specimen from the Karoo Formation (probably Triassic) of Cape Colony; *Oxygnathus* and *Platysiagum* are Liassic; and *Coccolepis* ranges from the Lias to the Purbeck Beds.

Wall-case, No. 8, and Table-cases, 39, 40.

The Platysomidæ are deep-bodied fishes closely related to the Palæoniscidæ, confined to the Carboniferous and Permian. *Eurynotus* (Fig. 143) is Lower Carboniferous; *Cheirodus*

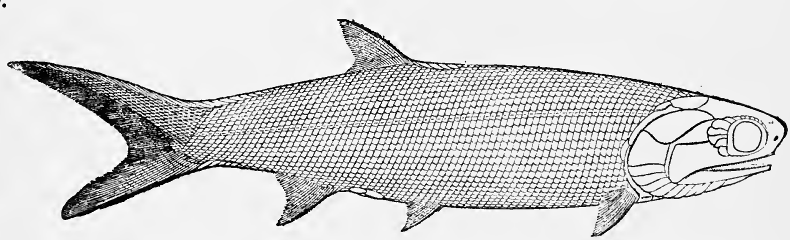


FIG. 142.—*Palæoniscus macropomus*, Ag. (restoration by Dr. R. H. Traquair); Kupferschiefer, Germany.

and *Mesolepis* are best known in the Coal Measures; *Platysomus* (Fig. 144) is both Carboniferous and Permian.

These fishes all have strongly heterocercal tails, but there is one family (that of Catopteridæ) in the Trias, in which the

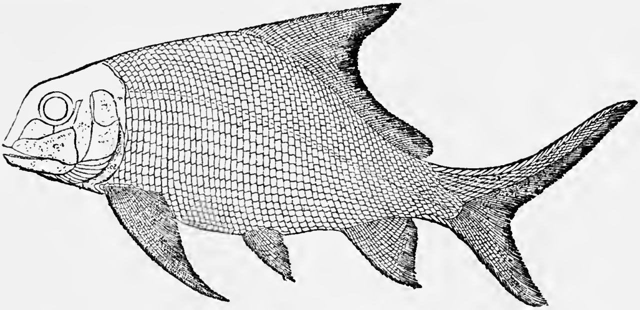


Fig. 143.—*Eurynotus crenatus*, Agassiz (restoration by Dr. R. H. Traquair); "Cement-stones," Carboniferous Series of Scotland.

tail is hemi-heterocercal and the rays of the dorsal and anal fins are nearly as few as their supporting cartilages. They are represented by *Dictyopyge*, from Europe, North America, and Australia, and by *Catopterus* from North America. They are a distinct link between the Chondrosteans and the great majority of Mesozoic fishes. **Wall-case, No. 8, and Table-case, No. 40.**

Here are also placed the Belonorhynchidæ, which are elongated fishes with much-produced snout, diphycercal tail, and the trunk only armoured with four longitudinal rows of scutes—one dorsal, another ventral, and one along the course of the "lateral line" on each side. Skeletons of the small *Belonorhynchus striolatus* from the Upper Trias of Raibl, Carinthia, and fine skulls of larger species from the Lower Lias of Lyme Regis and the Upper Lias of Würtemberg, are exhibited. **Table-case, No. 40.**

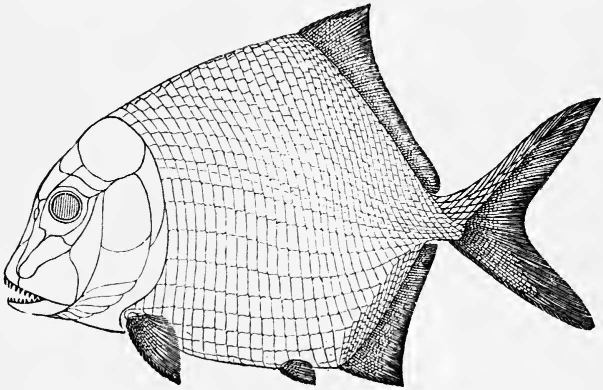


Fig. 144.—*Platysomus striatus*, Agassiz (restoration by Dr. R. H. Traquair); Magnesian Limestone, Durham.

ORDER—**Actinopterygii.** SUB-ORDER—**Chondrostei.**

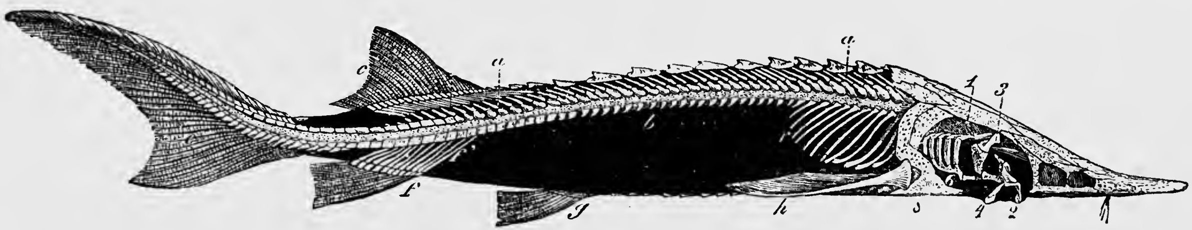


FIG. 145.—Skeleton of Sturgeon (*Acipenser*).

1, posterior extremity of cartilaginous cranium beneath the head-plates; 2, upper jaw; 3, hyomandibular bone; 4, lower jaw; 6, gill-arches; 8, pectoral arch; *a*, neural arches and spines, placed above the notochord; *b*, hæmal arches, placed below the notochord; *c*, dorsal fin; *e*, caudal fin; *f*, anal fin; *g*, pair of pelvic fins; *h*, pair of pectoral fins; *r*, ribs.

The Rhætic teeth named *Saurichthys* belong to a very similar fish.

The Chondrosteidæ, represented by *Chondrosteus* (Fig. 146) from the Lower Lias of Lyme Regis, perhaps also by the gigantic *Gyrosteus* from the Upper Lias of Whitby, are intermediate between the Palæoniscidæ and the modern sturgeons. The fine specimens exhibited show that the skeleton is identical with that of the sturgeons (Fig. 145), and that the jaws are reduced and toothless; but the roof of the skull and the development of the branchiostegal rays more closely resemble the corresponding parts in Palæoniscids. **Wall-case, No. 7.**

A few dermal scutes identical with those of the existing sturgeon, *Acipenser*, are shown from the English Eocene. There are also pectoral fin-spines both from the Eocene and Pliocene. **Table-case, No. 40.**

Sub-order II.—**Protospondyli.**

The large majority of Mesozoic fishes are closely related to the existing "bony pike" (*Lepidosteus*) and "bow-fin" (*Amia*) of North American lakes and rivers. They have the upper lobe of the tail excessively abbreviated, the rays of the dorsal and anal fins equal in number to their supports, and no infraclavicular plates in the pectoral arch. They are represented in the Collection by a very extensive series of specimens.

The first family is that of the Semionotidæ, already represented by one genus of small fishes, *Acentrophorus*, in the Upper Permian. They are stout-bodied, with a small mouth and blunt, often powerfully crushing teeth. *Semionotus* and *Colobodus* are Triassic and Rhætic; *Dapedius* (Fig. 147) is Liassic; and *Lepidotus* (Fig. 148) ranges from the Rhætic to the Wealden. The powerful dentition of *Lepidotus*, originally named *Sphærodus*, is particularly noteworthy; the successional teeth when first formed in the jaw are directed away from those they are destined to replace, and gradually turn through an angle of 180° as they come into use. **Wall-cases, Nos. 9 to 11. Table-case, Nos. 40, 41.**

The Macrosemiidæ are elongated fishes with small mouth, obtuse teeth, and extended dorsal fin, ranging from the Rhætic to the Chalk. Fine examples of *Ophiopsis* and *Macrosemius* are shown from the Lithographic Stone of Bavaria and France, others of *Ophiopsis* and *Histionotus* from the Purbeck Stone of Dorsetshire and Wiltshire. **Table-case, No. 41.**

The Pycnodontidæ (thick-teeth) are a remarkable family of deep-bodied fishes, so-called in allusion to the powerful grinding teeth (Fig. 149) which arm their forwardly-displaced mouth. The rhombic scales are usually so thin, that their ribbed front margin is often the only part preserved, producing the appearance of a series of parallel streaks from the upper to **Wall-case, No. 11, and Table-cases Nos. 42, 43.**

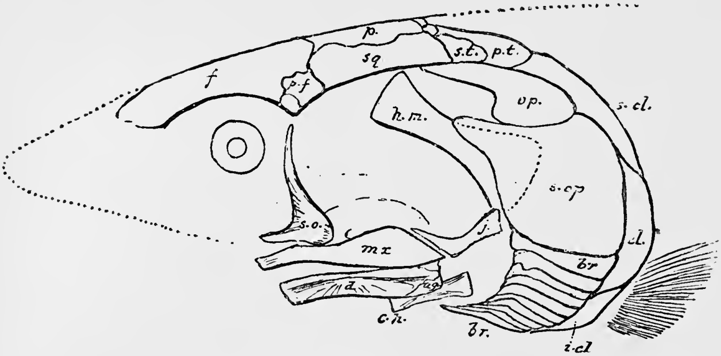


Fig. 146.—Restoration of Head of *Chondrosteus acipenseroides*, Ag. (after Traquair); Lower Lias, Lyme Regis.

ag, angular bone; *br*, branchiostegal rays; *ch*, ceratohyal; *cl*, clavicle: *d*, dentary bone of mandible; *f*, frontal; *hm*, hyomandibular; *j*, jugal; *i.cl*, infraclavicle; *mx*, maxilla; *op*, operculum; *p*, parietal; *p.f*, postfrontal; *p.t*, post-temporal; *s.cl*, supraclavicle; *s.o*, suborbital; *s.op*, suboperculum; *s.t*, supratemporal; *sq*, squamosal.

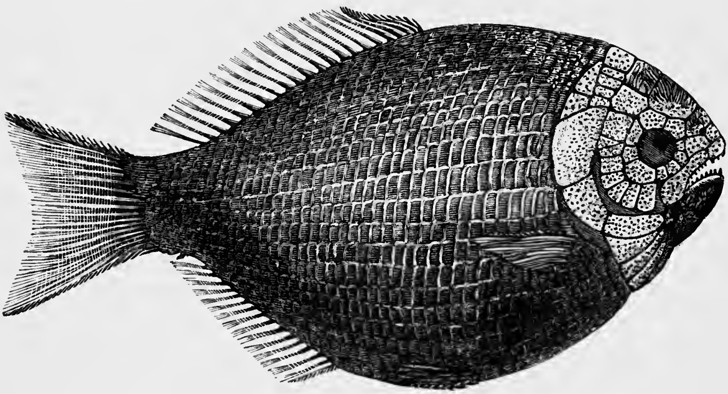


Fig. 147.—*Dapedius politus*, Leach; Lower Lias, Lyme Regis, Dorset.

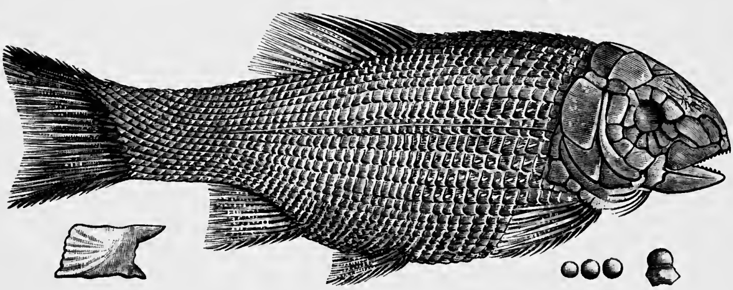


Fig. 148.—*Lepidotus maximus*, Wagn.; Lithographic Stone (Upper Oolite), Bavaria.

the lower margin of the trunk. In several genera (*e.g. Mesodon*, *Microdon*, and *Cœlodus*) the tail is destitute of scales. These fishes range from the Lower Lias (*Mesodon liassicus*) to the Upper Eocene (*Pycnodus platessus*) with very little modification. The fine series of examples of *Gyrodus* from

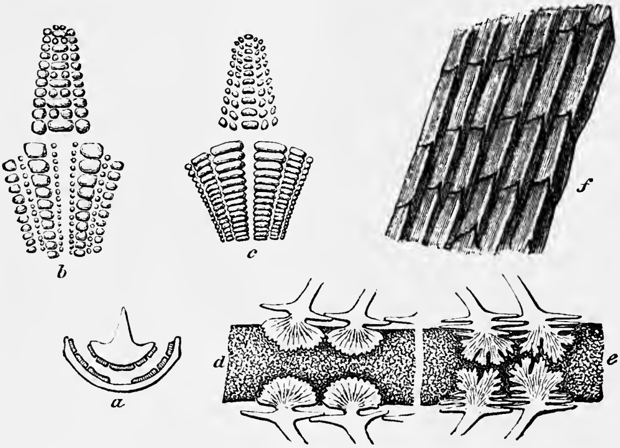


FIG. 149.—Portions of Pycnodonts. *a*. transverse section of jaws, showing the two halves of the mandibular dentition opposing the vomerine teeth; *b*, dentition of *Microdon*; *c*, dentition of *Cœlodus*; *d*, portion of vertebral column of *Cœlodus*, showing persistent notochord (shaded), and the expanded bases of the arches; *e*, the same of *Pycnodus*; *f*, inner view of scales, showing mode of interlocking by pegs and sockets, which are continued as longitudinal ribs.

the Lithographic Stone of Bavaria, and of *Palæobalistum* from the Hard Chalk of Mount Lebanon, are particularly worthy of attention. The armoured *Coccodus* and *Xenopholis* from Mount Lebanon are also remarkable. None of these fishes have vertebræ, but in the later genera the arches above and below the notochord are often expanded to unite at the side (Fig. 149).

The Eugnathidæ are the rhombic-scaled forerunners of the modern *Amia* (Fig. 150), and range from the Upper Trias or Rhætic to the Chalk. They are predaceous fishes with a large

Wall-cases, Nos. 12, 13, Table-cases, Nos. 43, 44.

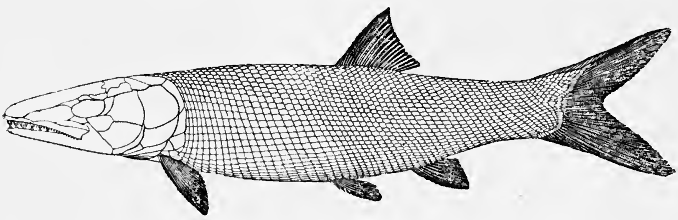


FIG. 151.—*Eugnathus orthostomus*, Ag.; Lower Lias, Lyme Regis.

ORDER—**Actinopterygii.** SUB-ORDER—**Protospondyli.**

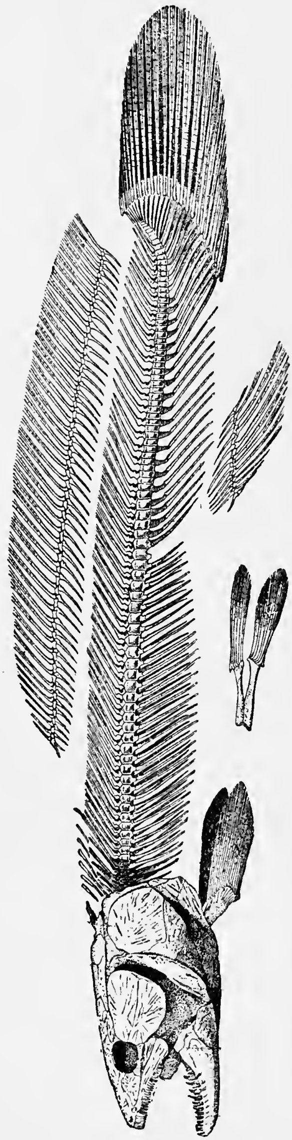


FIG. 150.—*Amia calva*, Linn.; skeleton of recent fish from freshwaters of North America.

mouth and conical teeth. The thick-scaled *Eugnathus* (Fig. 151) and the thin-scaled *Caturus* (Fig. 152) both range throughout the Jurassic, the specimens from the Lower Lias of Lyme

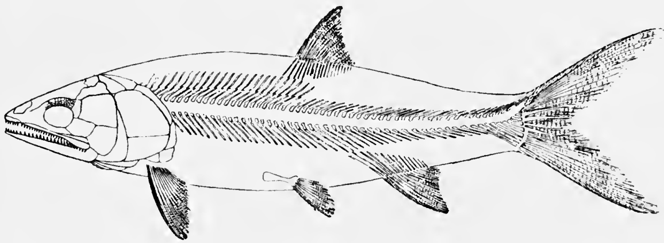


FIG. 152.—*Caturus furcatus*, Ag.; Lithographic Stone, Bavaria. [Scales omitted.

Regis and the Lithographic Stone of Bavaria being particularly fine. *Neorhombolepis* is an interesting fish from the English Chalk and Wealden, with rhombic enamelled scales and disc-shaped vertebræ.

Wall-case, No. 13, and Table-case, No. 44.

The Amiidæ are first certainly represented in the Upper Jurassic. *Megalurus*, from the Lithographic Stone of Bavaria and France and from the English Purbeck Beds, is very similar to *Amia* but has a shorter dorsal fin. The existing genus is represented by fine specimens from the Lower Miocene of France, and is also known in Germany. Detached vertebræ are shown from the Lower Tertiaries of the Hampshire Basin.

Wall-cases, Nos. 13, 14. Table-case, No. 45.

A family of Amioids which curiously mimic the modern sword-fishes, ranges throughout the Jurassic and Cretaceous periods, and is represented by *Pachycormus* (Upper Lias), *Hypsocormus* (Oxfordian and Kimmeridgian), and *Protosphyræna* (Upper Cretaceous), besides other genera. The notochord is persistent, but to strengthen the trunk the vertebral arches are multiplied and very closely arranged; the powerful forked tail is supported by a triangular expansion of one of the hæmal bones; and the snout gradually becomes elongated until it is a formidable weapon in *Protosphyræna*.

SUB-ORDER III.—**Aetheospondyli.**

Wall-case, No. 14, and Table-case, No. 45.

Next to the Pachycormidæ, in an uncertain position, are placed the Aspidorhynchidæ and the modern Lepidosteidæ, the former ranging from the Lower Oolites to the Upper Chalk, the latter exclusively Tertiary. *Aspidorhynchus* (Fig. 153), with prominent rostrum, is represented by a fine series of specimens from the Lithographic Stone of Bavaria; the closely-related *Belonostomus*, with elongated jaws but little or no prominent rostrum, is shown both from this formation and in a unique

Table-case, No. 45.

collection of nodules from the Upper Cretaceous of Brazil. Of the existing American genus *Lepidosteus*, there are numerous fragments of skulls, characteristic vertebræ, and scales from the English Eocenes; and similar specimens are found both in France and Germany.

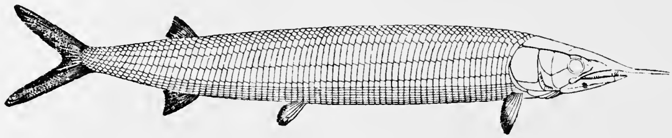


FIG. 153.—*Aspidorhynchus ornatissimus*, Ag.; Lithographic Stone, Bavaria.

All the preceding fishes have a complex lower jaw, each half consisting of at least four or five pieces; and when the teeth are powerful, those on the inner (or splenial) element are specially well-developed. In all the following groups the lower jaw consists normally of only two pieces on each side, one behind (articulo-angular) and a larger piece (dentary) in front.

SUB-ORDER IV.—**Isospondyli.**

Table-case, No. 46.

Table-case, No. 15, and Table-cases, Nos. 47, 48.

The first and earliest group of the higher fishes is that in which the vertebræ never fuse into a complex behind the head, in which the simple air bladder is directly connected with the gullet, and in which the pelvic fins are always situated well behind the pectorals. Here may be placed the Pholidophoridæ which are remarkably like the herrings in general aspect, but have only ring-vertebræ, ganoid scales, and fulcra on all the fins. *Pholidophorus* itself ranges from the Rhætic to the Purbeck Beds, but is especially well represented by a large series of specimens from the Lower Lias of Lyme Regis. Some diminutive fishes of the genera *Peltopleurus* (Upper Trias) and *Pleuropholis* (Kimmeridgian and Purbeckian) exhibit a series of remarkably deepened scales on the flank. The Oligopleuridæ, ranging from the Upper Jurassic to the Upper Cretaceous, come next. The Leptolepidæ follow, with *Leptolepis*, *Aethalion*, and *Thrissops*,

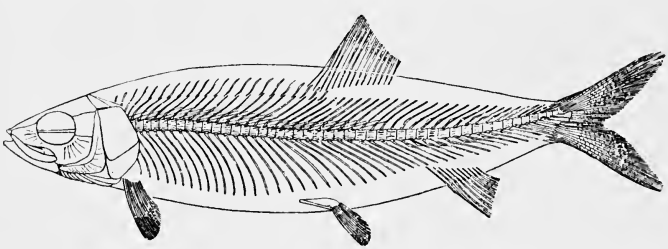


FIG. 154.—*Leptolepis dubius*, Blainv. sp.; Lithographic Stone, Bavaria. [Scales omitted.]

mostly from the Lithographic Stone of Bavaria; and these differ from the herrings (Clupeidæ) chiefly in the meeting of the parietal bones and in the simple character of the tail. *Leptolepis* (Fig. 154) is first represented by small species in the Upper Lias of England, France, and Würtemberg.

"Ganoid" and "Teleostean."

Either here or immediately after the "Amioids" (the Pholidophoridæ having previously been classed with the "Lepidosteoids"), it has long been customary to recognize a break in the series of Teleostomatous fishes. All groups below have been united under the name of Ganoidei (enamelled-scaled fishes); all above have been termed Teleostei (bony-fishes). This arrangement was very convenient so long as the extinct families were more incompletely known; but fossils now show that it cannot be scientifically maintained, and the terms "Ganoid" and "Teleostean" must thus be employed in future merely in a general way for enamelled-scaled and modern bony fishes respectively.

Most of the so-called "Teleostean" fishes have a remarkably developed internal skeleton, as may be perceived from the

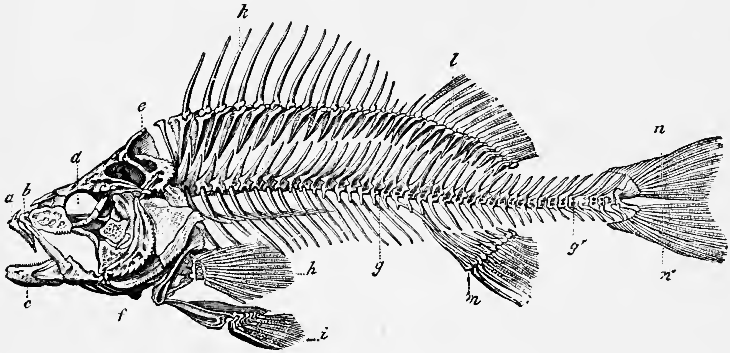
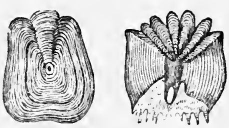


Fig. 155.—Skeleton of the Common Perch.

a, premaxillary bone; *b*, maxillary bone; *c*, lower jaw; *d*, palatine arch; *e*, cranium; *f*, interoperculum; *g g′*, vertebral column; *h*, pectoral fin; *i*, pelvic fin; *k*, spinous dorsal fin; *l*, soft dorsal fin; *m*, anal fin; *n*, upper, and *n′*, lower lobe of caudal fin.

[The pectoral and pelvic fins each form a pair, and correspond respectively to the anterior and posterior pairs of limbs of the higher vertebrata. The dorsal, caudal ,and anal fins are median and unpaired.]



A. B.

Fig. 156.—Scales of Teleostean Fishes. A, Cycloid; B, Ctenoid.

accompanying figure of that of the common perch (Fig. 155). Very few are covered with bony scales, the large majority being invested with thin and flexible, deeply-overlapping scales which are either smooth ("cycloid," Fig. 156A), or pectinated ("ctenoid," Fig. 156B), at the hinder margin.

Table-case, No. 49.

Next to the Leptolepidæ are arranged the representatives of the lowest of the truly bony fishes which still survive, namely, the herring-like family Elopidæ, which comprises several genera exhibiting a gular plate like that of *Amia*. Among these, the finest are the examples of *Osmeroides* and *Aulolepis* from the English Chalk, long supposed to be Salmonidæ. The series in the table-case includes the type-specimens from the collection of the late Dr. Mantell, and several beautifully worked out of the chalky matrix by this distinguished pioneer in palæontology. Those of *Osmeroides* are especially perfect, and, like most fossil fishes from the Chalk, they are almost uncompressed, the fine calcareous particles having replaced the muscular and other tissues as rapidly as they were destroyed by decomposition, thus preventing the collapse of the flanks, and preserving the natural rotundity and form of the fish when living. Other closely-related genera are *Thrissopater* from the Gault of Folkestone, and *Rhacolepis* in nodules from the Upper Cretaceous of Brazil.

Table-case, No. 50.

The Clupeidæ, or herrings-proper, date back to the Cretaceous, where they are represented both in Mount Lebanon and

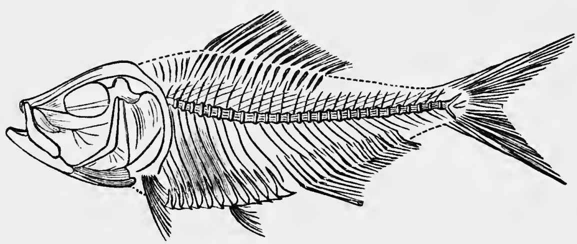


Fig. 157.—*Diplomystus brevissimus*, Blainv. sp. (after Pictet and Humbert); Upper Cretaceous, Mount Lebanon.

Brazil by *Diplomystus* (Fig. 157), which only seems to differ from the modern *Clupea* in the possession of a series of scutes between the back of the head and the dorsal fin. This fish is also common in the European and North American Lower Tertiaries, and still survives in the rivers of Chili and New South Wales. *Clupea* itself may date back to the Eocene, but this is uncertain. *Scombroclupea* (with finlets behind the anal), *Rhinellus* (Fig. 158), *Leptosomus*, *Chirocentrites*, and other fishes from Mount Lebanon, are also believed to be Clupeoids.

It is interesting to notice that in the Syrian area, owing to some physical change in the conditions of the sea at the time the Cretaceous deposits were being laid down, these fishes appear to have been sometimes suddenly destroyed in shoals, and buried at once by the fine calcareous mud. This circumstance is well illustrated in Wall-case No. 15, by several slabs

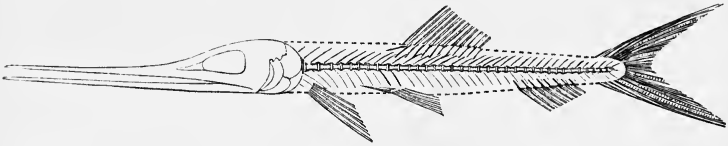


FIG. 158.—*Rhinellus furcatus*, Ag. (after Pictet and Humbert); Upper Cretaceous, Mount Lebanon.

of fossil limestone from Hakel, near Beyrout, which are covered with hundreds of their remains.

The Salmonidæ are scarcely known among fossils and very difficult to distinguish from the Clupeidæ. It is usually possible only to recognise the genera which still exist. Some surviving

Table-case, No. 49.

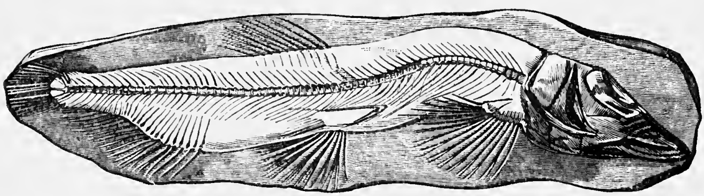


FIG. 159.—Capelin (*Mallotus villosus*), in nodule of Glacial Clay, Greenland.

species are found fossilized in comparatively recent deposits, and an interesting series of nodules is exhibited from the glacial clays of Greenland, Norway, and the banks of the Ottawa River, Canada, each enveloping a "Capelin" (*Mallotus villosus*). The shape of the nodule (Fig. 159) in each case is observed to correspond precisely with the contour of the enclosed fish, and the concretion is probably due to the escape of gases from the decomposing body leading to a concentration of mineral matter at the spot from the clay around it.

Near the Salmonidæ are placed the remains of the Cretaceous family of Saurodontidæ, which have powerful teeth implanted in distinct sockets on the margin of the jaw. *Portheus* attains a large size, as shown by the very fine slab of *Portheus molossus* from the Chalk of Kansas, U.S.A., exhibited in Wall-case No. 16. More fragmentary specimens are shown from the English Chalk. Closely allied are *Ichthyodectes* and *Saurocephalus*.

Wall-case, No. 16, and Table-case, No. 49.

The large Cretaceous fish *Pachyrhizodus* (= *Hypsodon* in part) is also perhaps related to the Salmonoids. It has powerful conical teeth firmly fixed to the jaws, and fragments from the English Chalk have been erroneously referred to reptiles.

Wall-case, No. 16.

Table-case, No. 51.

The Scopelidæ and allied families are probably represented in the Upper Cretaceous by the fishes named *Spaniodon*, *Enchodus*, and *Eurypholis* (Fig. 160), some of which from

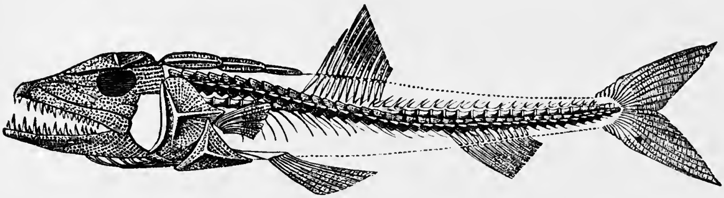


FIG. 160.—*Eurypholis Boissieri*, Pict. (after Pictet and Humbert); Upper Cretaceous, Mount Lebanon.

Westphalia (not in the Collection) exhibit distinct traces of an adipose dorsal fin. They have very irregularly developed large teeth within the mouth, and *Eurypholis* exhibits ornamented dermal scutes both on the anterior part of the back and along the lateral line. *Cimolichthys* and *Pomognathus* from the English Chalk also seem to be related to these fishes. *Phylactocephalus* from Mount Lebanon is probably identical with *Pomognathus*.

Typical Scopelidæ are *Parascopelus* and *Anapterus* from the Upper Miocene of Licata, Sicily.

Table-case, No. 51.

The extinct Cretaceous family of Hoplopleuridæ follows next, comprising much-elongated fishes wanting true scales but armoured with longitudinal series of scutes. *Dercetis* (*Leptotrachelus*) occurs in the English Chalk, and still more abundantly in the Upper Cretaceous of Mount Lebanon. *Pelargorhynchus* is an allied fish from the Chalk of Westphalia.

SUB-ORDER V.—**Plectospondyli.**

Wall-case, No. 16, and Table-cases, Nos. 52, 53.

Remains of Cyprinidæ are not uncommon in freshwater formations above the Eocene both in Europe and North America, but almost all the extinct species are referable to existing genera. The true Carp (*Cyprinus*) and Gudgeon (*Gobio*) occur in the Miocene of Oeningen. Species of *Leuciscus* (Roach, Dace, Minnow, etc.) are represented in the same deposit, in the lignites of France and Germany, and in the Upper Miocene Infusorial Earth of Licata, Sicily. The latter formation also yields remains of other genera, *e.g.* *Rhodeus* and *Aspius*; and as Herrings, Scopeloids, etc., occur abundantly in association with these, the mingling of marine and freshwater fishes is here very remarkable. The Tench (*Tinca*) is found in the Oeningen beds and Tertiary lignites; and the little *Acanthopsis*, now of Tropical India, is met with in the Miocene of the Puy-de-Dôme, France. Other genera exhibited are *Barbus*, *Thynnichthys*, *Amblypharyngodon* and *Hexapsephus*, from the Eocene of Padang, in Sumatra; also *Cobitis* from Oeningen.

Sub-order VI.—**Nematognathi.**

The remarkable family of Siluridæ, or "Cat-fishes," though so widely distributed at the present day, is very imperfectly known among fossils. The earliest known member of the family is *Bucklandium diluvii*, represented by a skull from the London Clay of Sheppey. The Bracklesham beds and Barton Clay yield evidence of a fish indistinguishable in its head from the living genus *Arius*, and named *Arius egertoni*. Remains of several other forms from the Siwalik Hills, India, and the highlands of Padang, Sumatra, are also exhibited; these being mostly allied to species still living in those regions. **Table-case, No. 53.**

Sub-order VII.—**Haplomi.**

The Pikes (Esocidæ) and toothed Carps (Cyprinodontidæ) are not certainly known below the Lower Miocene or Oligocene. A true *Esox* occurs in the Miocene of Oeningen, Switzerland. There are also fragments of the existing *Esox lucius* from the peat of the Fenland. Most of the fossil species of toothed Carps seem to belong to the living genus *Cyprinodon* (*Lebias*) or a very close ally, and numerous specimens are shown from the Upper Eocene deposits of Aix in Provence, the Miocene of Oeningen, and the equivalent lignites of Central France and Germany. The fishes from Aix are frequently found buried in shoals, as is well shown by slabs of marl covered with their remains exhibited in the case. Very singular is the occurrence of the genus *Pœcilia* in the Oeningen beds, this being now confined to the freshwaters of Tropical America. **Wall-case, No. 16.** **Table-case, No. 52.**

Sub-order VIII.—**Apodes.**

The "Eels" are spread at present over almost all the freshwaters and seas of the temperate and tropical zones, and the earliest of their fossil remains hitherto discovered are from the Upper Cretaceous of Mount Lebanon. Beautiful examples of these are exhibited in the case. The genus *Rhynchorhinus*, of the London Clay, seems to be rightly placed in this family; and in the beds of Monte Bolca there are representatives of the living genera *Anguilla*, *Ophichthys*, and *Sphagebranchus*, in addition to numerous specimens of the so-called *Leptocephali*, which are supposed to be undeveloped larval forms. Later de- **Table-case, No. 52.**

posits, like the Miocene of Oeningen, Switzerland, and the Upper Eocene of Aix in Provence, France, have also yielded species of *Anguilla*, and some fine examples from the first-named locality are preserved in the collection.

Sub-order IX.—**Anacanthini.**

This sub-order, which comprises the symmetrically-formed Cod-fishes (*Gadoidei*) and the remarkably unsymmetrical Flat-fishes (*Pleuronectoidei*), is not known to have many representatives in the fossil state. None of the fins have spinous rays (hence the name); the median fins are almost invariably well developed; and the pelvic fins, when present, are either thoracic or jugular in their position.

Wall-case, No. 17.

Nemopteryx and *Palæogadus* are Gadoids from the black slates of Glaris; other undescribed forms occur in the London Clay of Sheppey; and a small recent *Gadus* is shown in a nodule from Glacial Clay, Bindalen, Norway.

Table-case, No. 53.

The "Flat-fishes" are characterized, except in the very young state, by the peculiar habit of constantly swimming and resting upon one side, the fore part of the head, with both eyes, becoming gradually twisted to the upper or opposite side in the adult. Species equally modified or "specialized" are met with even in the Eocene of Monte Bolca, where the living *Rhombus* occurs; and there are small kinds of "Sole" (*Solea*) in the Miocene of Ulm, Würtemberg; it is remarkable, however, that no less-altered ancestral types have hitherto been recognised.

Sub-order X.—**Percesoces.**

Table-case, No. 53.

The Scombresocidæ, Atherinidæ, Mugilidæ, and Sphyrænidæ are not definitely known below the Upper Eocene, though *Rhinellus*, from the Upper Chalk of Mount Lebanon and Westphalia, may belong to the first family. The Atherinidæ are represented by *Mesogaster* in the Upper Eocene of Monte Bolca, and the Mugilidæ ("Grey Mullets") apparently by *Mugil* itself in the corresponding beds of Aix in Provence. The great voracious "Barracudas" (Sphyrænidæ) of the West Indies and other tropical seas, also have small representatives at Monte Bolca.

Sub-order XI.—**Pharyngognathi.**

This is a group of spiny-finned fishes characterized by the coalescence of their two lower pharyngeal bones, which support a powerful dentition.

The true "Wrasses" (*Labrus*) appear to be represented in the Eocene of Monte Bolca, and an extinct family, the Pharyngodopilidæ, is indicated by some pharyngeal dental plates from the London Clay of Sheppey, and the Lower

Table-case, No. 53.

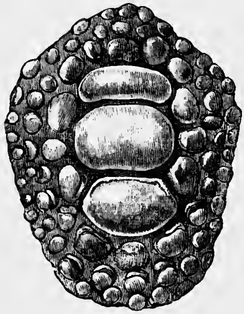


FIG. 161.—Pharyngeal dentition of *Phyllodus petiolatus*, Owen; London Clay, Sheppey.

Tertiaries of the Continent. To the latter belong *Phyllodus* (Fig. 161) and *Pharyngodopilus* (*Nummopalatus*), and of the first-named genus, the collection now comprises nearly all the type-specimens described in Prof. Cocchi's Monograph on these fishes. *Phyllodus* is so called on account of the leaf-like shape of the entire pharyngeal dentition, and the separate teeth composing this are very thin and constantly replaced by vertical successors, which are arranged in little piles beneath the functional ones.

The remarkable fragments of dentition from the London Clay, known as *Egertonia*, and those from the Bracklesham Beds termed *Platylæmus*, are also supposed to be referable to extinct Pharyngognathi. *Taurinichthys*, from the French Miocene, is also placed here.

SUB-ORDER XII.—**Percomorphi.**

Pterygocephalus, from the Eocene of Monte Bolca, seems to represent the "Blennies" (Bleniidæ): extinct species of "Gobies" (Gobiidæ) are also found in the same formation, and in the Infusorial Earth of Oran, Algeria.

Petalopteryx, with huge pectoral fins, from the Cretaceous of Mount Lebanon, is perhaps an old "Flying-fish"—one of the *Cataphracti*. And the closely-allied "Millers' Thumbs" and "Gurnards" (Cottidæ) are represented in the Middle Tertiaries. *Lepidocottus*, almost identical with the living *Cottus*, except in possessing a covering of scales, is found in the Miocene of the Puy-de-Dôme, France; and a large series of these fishes is exhibited.

Table-case, No. 54.

Remains of true "Angler-fishes" (*Lophius*) have been discovered at Monte Bolca; and the Trachinidæ ("Stare-gazers," etc.) may possibly be represented by *Callipteryx* from the same locality. To the latter also certainly belong *Trachinopsis* from the Upper Tertiary of Lorca, Spain, and *Pseudoeleginus* from the Upper Miocene of Licata, Sicily.

able-case, No. 16. Wall-case, No. 54.

The Scombridæ—or Mackerel family—occur fossil in various Tertiary deposits. They may often be readily distinguished by the curious series of finlets, in most cases present behind the second dorsal and anal fins.

The "Tunny" (*Thynnus*) and an extinct genus, *Orcynus*, are met with at Monte Bolca: remains of *Cybium* are not uncommon in the London Clay: and three other extinct genera, *Archæus*, *Isurus*, and *Palimphyes*, occur in the black Eocene Slates of Canton Glaris.

Wall-case, No. 17.

To the Coryphænidæ—pelagic fishes with a single long dorsal fin and laterally-compressed body—Dr. Günther refers the *Gasteronemus* of Monte Bolca, which is perhaps not distinct from the living genus *Mene*. It is remarkable for the length of the spinous rays representing the pelvic fins, and several fine specimens are exhibited in the Wall-case. *Goniognathus*, from Sheppey, may also be placed here.

Wall-case, No. 17.

able-case, No. 54.

The Carangidæ, or "Horse-mackerels," constitute an extensive family of laterally-compressed deep-bodied fishes, abundantly represented at present and throughout the Tertiary period, comprising a few forms also in the Cretaceous. *Vomer*, *Aipichthys*, and *Platax*, have been described from the Chalk of Comen in Istria (Trieste), and *Platax* alone from that of Mount Lebanon: the last-named genus survives in existing seas (as the "Sea-bats") having also left traces of its presence in the Eocene of Monte Bolca, and the Crags of our Eastern counties. The Crag fossils are mere fragments of vertebral centra, neural spines, and interspinous bones; the spines are tumid in the middle, giving the broken pieces a curious appearance. *Semiophorus* (Fig. 162) is a remarkable extinct genus found at Monte Bolca, and characterized by the enormous development of the dorsal fin; the pelvic fins are long and slender, thoracic in position, and situated in advance of the pectorals, which are very small. *Lichia*, *Carangopsis*, and *Ductor*, are other Monte Bolca genera shown in the Wall-case; the first still exists, the second is scarcely distinguishable from the living *Caranx*, and the third appears to be extinct. *Amphistium*, from the same deposit and the Paris Eocenes, is another form referable to this family.

Table-case, No. 54.

Of the Acronuridæ, or "Surgeons," species pertaining to the living *Acanthurus* and *Naseus* are exhibited from the Eocene of Monte Bolca.

Wall-case, No. 17.

An extinct family, apparently most closely related to the

Trichiuridæ, is that of the Palæorhynchidæ. These are long, slender, laterally-compressed fishes, with a very delicate skeleton, and having the jaws prolonged into a sharply-pointed beak, either edentulous or provided with very small teeth. The dorsal fin is supported by spinous rays and extends along the entire length of the back, and the caudal fin is deeply forked. **Wall-case, No. 17.**

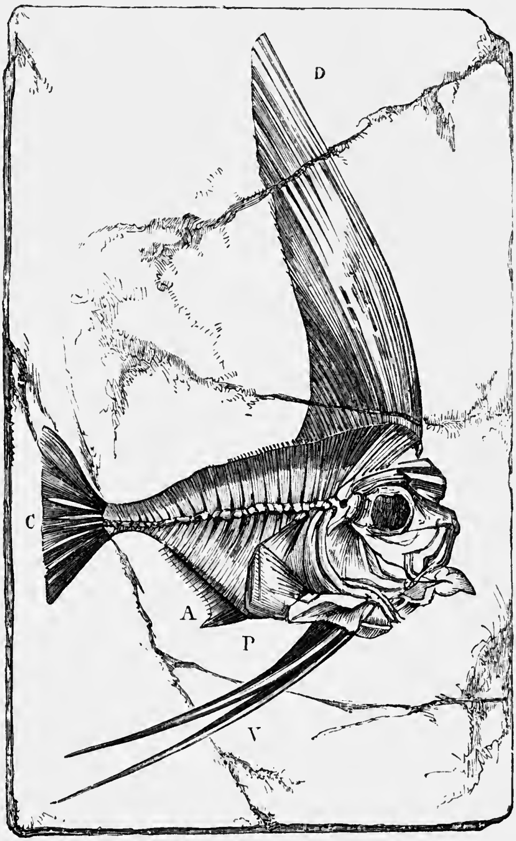


FIG. 162.—*Semiophorus velicans*, Agassiz, from the Eocene formation of Monte Bolca. A, anal fin; C, caudal; D, dorsal; P, pectoral; V, pelvic fins.

In *Palæorhynchum* the jaws are of equal length, and an extensive series of specimens is shown in the Wall-case, from the Eocene Slates of Canton Glaris. *Hemirhynchus*, which has the upper jaw much longer than the lower, occurs both in the Glaris beds and in the Lower Tertiaries of France and Belgium.

Wall-case, No. 17.

The Trichiuridæ ("Hair-tails," "Scabbard-fishes," etc.) differ most prominently from the preceding family in the powerful character of the jaws, which are armed with strong teeth, some usually much larger than the others. Representatives of the existing *Lepidopus* occur in the Eocene Slates of Glaris, and also in the Upper Miocene of Licata, Sicily. Owing to imperfections in the specimens, the former were originally placed in a distinct genus, *Anenchelum*, and the distortion of the fossils led to an undue multiplication of the so-called species.

Hemithyrsites and *Trichiurichthys* are scaly extinct forms from the Upper Miocene of Licata, Sicily, but there are no examples in the collection.

Table-case, No. 55.

Next to the Trichiuridæ are arranged the fragmentary remains of Xiphiidæ or "Sword-fishes." These, as is well known, are remarkable for the great length of the cuneiform snout; they are the largest of Acanthopterygian Fishes. The generic determinations of the fossil forms are still very doubtful, but a series of typical fragments is exhibited from the English Eocene.

Wall-case, No. 18.

Of the family of Berycidæ, a very large series of specimens is exhibited. These fishes have much the general appearance of the Perches, but there are large cavities in the head-bones connected with the sensory slime-canal system, and the pelvic fins have (except in one genus) more than five soft rays in addition to the spine. They are all marine. The living genus *Beryx* occurs both in the English Chalk and the Upper Cretaceous of Mount Lebanon. Many of the English examples, both of this and allied genera, are but slightly compressed, retaining their original form, and those from the collection of the late Dr. Mantell are especially fine; several are the type-specimens figured in the works of Agassiz and Mantell; and later acquisitions from Mr. Frederic Dixon's collection are the originals of figures in his well-known "Geology and Fossils of Sussex." *Hoplopteryx* is a genus with very powerful fin-spines, to which are referred the two English Chalk species commonly known as *Beryx ornatus* and *Beryx superbus*, besides other forms from the Cretaceous of Westphalia and Mount Lebanon. *Berycopsis* (with cycloid scales), *Homonotus*, and *Stenostoma* are other genera of the English Chalk. *Pseudoberyx* (with almost abdominal pelvic fins) occurs at Mount Lebanon, and *Sphenocephalus* and *Acrogaster* in the Westphalian Cretaceous deposits. The living surface-dwelling genera, *Myripristis* and *Holocentrum*, are not uncommon at Monte Bolca, and the latter has also been discovered in the Miocene of Malta.

The carnivorous marine family of Scorpænidæ is represented in the fossil state by a species of *Scorpæna* in the Infusorial Earth of Oran, Algeria, but there are no specimens in the collection.

The Sparidæ, or "Sea-breams," have numerous extinct congeners. They are Perciform Acanthopterygians with a curiously specialized dentition, the front teeth being usually adapted for piercing and cutting, and those at the sides of the mouth for crushing. Their earliest representatives, from the Cretaceous of Mount Lebanon, appear to be referable to the living genera, *Pagellus* and *Sargus;* and both these fishes are again found in the Tertiaries, the former at Monte Bolca, and the latter in France and at Oran, Algeria. *Sparnodus* (Fig. 163) is an extinct genus from Monte Bolca, having the teeth somewhat "spaced out"—hence the name. *Soricidens* and *Capitodus* are founded upon detached teeth from various European Tertiaries. Teeth of the living *Chrysophrys* are exhibited from the Miocene of Malta, the Crag of Suffolk, and from probably equivalent deposits in the Canary Islands. **Table-cases Nos. 55, 56.**

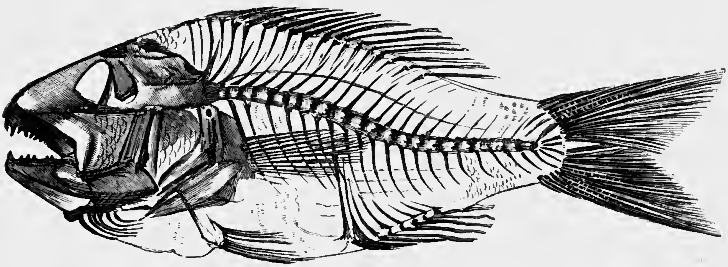


FIG. 163.—*Sparnodus ovalis*, Ag.; Upper Eocene, Monte Bolca.

The Squamipinnes are short, deep-bodied fishes, characterized, as their name denotes, by the extension of the scales over more or less of the dorsal and anal fins. The living forms ("Coral-fishes") are mostly brightly coloured fishes which abound in the neighbourhood of Coral-reefs. *Platycormus*, from the Upper Cretaceous of Westphalia, seems to be their earliest known representative; and there are remains of *Scatophagus*, and the living genera *Ephippium*, *Pomacanthus*, *Holacanthus*, in the Eocene of Monte Bolca. *Pygæus*, from the same formation, is also placed in this family. **Table-case, No. 56.**

The Percidæ, or Perch family, may perhaps be regarded as the highest—the most specialized—of Teleostean fishes; they are well represented both in the freshwater and marine Tertiary formations. The extinct genus *Smerdis*, with large deeply-forked tail (Fig. 164), occurs in the Miocene of Ulm, Würtemberg, and Puy-de-Dôme, France; in the Upper Eocene of Monte Bolca and Aix in Provence. *Lates*, *Cyclopoma*, and species of the living marine genera, *Dules*, *Serranus*, *Apogon*, *Therapon*, and *Pristipoma*, are also found at Monte Bolca. **Wall-case, No. 18. Table-case, No. 56.**

Table-case, No. 56.

Acanus is an extinct genus, originally referred to the Berycidæ, from the Eocene Slates of Canton Glaris, Switzerland.

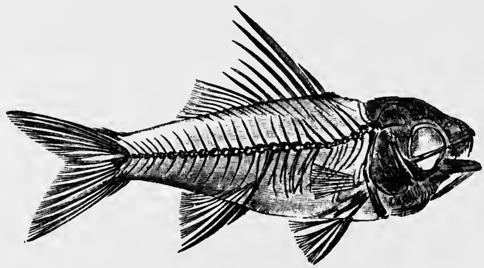


FIG. 164.—*Smerdis minutus*, Ag.; Eocene, Aix in Provence, France.

SUB-ORDER XIII.—**Lophobranchii.**

These are a small sub-order of bony fishes having the gills not laminated, but in the form of small rounded lobes or tufts. The gill-cover is reduced to a large simple plate; and the body is more or less encased in hard scales, arranged in segments.

Table-case, No. 56.

Here are placed the "Pipe-fishes" and "Sea-horses," which have but few fossil representatives. An extinct species of *Siphonostoma* is exhibited from the Miocene of Licata, Sicily; and there is also an ancient type of "Sea-horse"—*Calamostoma*—differing from the living *Hippocampus* in the possession of a caudal fin, from the Eocene of Monte Bolca. Another "Pipe-fish," *Solenorhynchus*, has been found in the Eocene of Monte Postale.

SUB-ORDER XIV.—**Hemibranchii.**

The Fistulariidæ, or "Flute-Mouths," which have been aptly described as "gigantic marine sticklebacks," are first known from the Eocene formation. Fossil remains of the two living genera, *Fistularia* and *Aulostoma*, occur at Monte Bolca and in the Slates of Canton Glaris; and *Auliscops*, another existing form, has been found at Padang, in the Tertiary lignites of the Island of Sumatra. The Monte Bolca deposits also yield two extinct genera, *Urosphen* and *Rhamphosus*: the latter has an immense spinous ray, denticulated behind, inserted on the nape, well shown in the specimen in the case.

SUB-ORDER XV.—**Plectognathi.**

The Plectognathi are remarkable for their dermal skeleton and were originally placed by Agassiz among the "Ganoids" on account of the characters of their armour. Some of these fishes (*e.g.*, *Ostracion*) have the integument converted into a continuous mosaic of hexagonal scutes; in others (*e.g. Diodon*), the skin is covered with numerous isolated spiny ossifications; while others are almost destitute of hard dermal structures. The pelvic fins are either absent or merely represented by spines; and the bones of the upper jaw are nearly always firmly united.

FIG. 165.—Teeth of *Diodon Scillæ*, Ag.; Miocene, Malta.

The sub-order is divided into the two families of Sclerodermi and Gymnodontes, the former of which have the jaws armed with distinct teeth, while the latter are provided with a kind of edentulous beak. Fossil Sclerodermis, in an excellent state of **Table-case, No. 56** preservation, are found in the Eocene Slates of Glaris, where two extinct genera, *Acanthoderma* and *Acanthopleurus*, occur. A species of *Ostracion* has been described from the Eocene of Monte Bolca; and *Glyptocephalus* appears to be another representative of the family in the London Clay of Sheppey. The Gymnodonts also date back to Eocene times. Fine specimens of *Diodon* ("Sea-hedgehogs") are exhibited from Monte Bolca and the Infusorial Earth of Oran, Algeria; and the little piles of dental plates (Fig. 165), placed within the mouth of the same genus, are found in the Miocene of Malta, Sicily, and other localities. *Enneodon* is a closely allied extinct genus, from the Middle Eocene of Monte Postale, N. Italy.

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W. H. FLOWER,

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