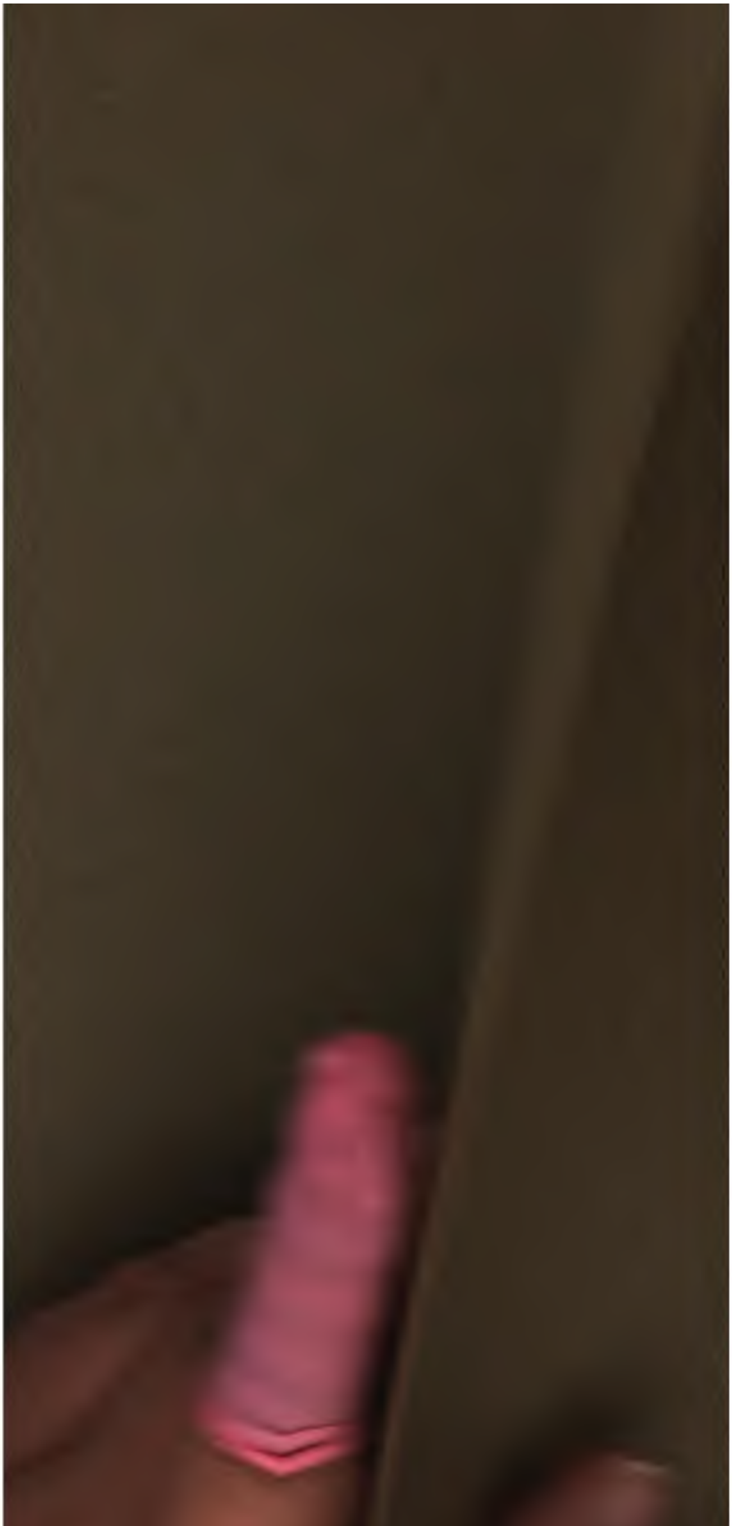

A
MANUAL OF PALÆONTOLOGY

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FOR THE USE OF STUDENTS

WITH A GENERAL INTRODUCTION ON THE PRINCIPLES OF PALÆONTOLOGY

BY

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ADDENDA ET CORRIGENDA TO PART III.

Page 901, line 13 from bottom, *for* "Weinsheimer" *read* "Wied heim."

" 912, line 2 from top, *for* "Teleotomi" *read* "Teleostomi."

" 928, line 17 from top, *for* "*Hypocladodus*" *read* "*Hybocladod*

" 928, line 8 from bottom, *for* "*Scilliidæ*" *read* "*Scylliidæ.*"

" 944. *Carcharopsis* is identical with *Dicrenodus* (p. 928).

" 945, line 6 from bottom, *before* "no basal" *add* "usually."

" 951. *Myriacanthus* has recently been made the type of a disti family—the *Myriacanthidæ* (see Appendix).

" 955. *Ceratodus* has recently been recorded from the Stormb beds of the Karoo system of S. Africa.

" 965. *Pnigeacanthus* is identified with *Oracanthus* (p. 947).

" 966, line 11 from top, *before* "very minute" *add* "usually."

" 966, line 5 from bottom, *dele* "minute."

" 967, line 4 from top, *for* "Carboniferous" *read* "Devonian."

" 969, line 9 from top, *dele* "and Carboniferous."

" 971, fig. 905, *for* "*Heberti*" *read* "*Hibberti.*"

" 978. *Palæoniscus* occurs in the Stormberg beds of the Karoo tem of S. Africa; and from the underlying Beaufort beds a allied to *Rhabdolepis* has lately been described as *Atherston*

" 979. The name "*Platysomidæ*" should be amended to "*Plat matidæ.*"

" 988, line 22 from bottom, *dele* "as in *Belonorhynchus.*" genus *Belonorhynchus* has recently been described from Australian Hawkesbury beds; while *Belonostomus*, or a clo allied form, is recorded from the Lameta Cretaceous of Indi

" 989. *Hypsicormus* has been recently described from the Oxf Clay, and *Eurycormus* from the Kimeridge Clay of England

" 1004, line 20 from bottom, *for* "*Saurinichthys*" read "*Taurin thys.*"

" 1033. A species of *Bothriceps* has been recently recorded from Karoo system of S. Africa.

Page 1035. The name *Platyops* being preoccupied, may be changed to *Platyopsaurus*. The genus should apparently be included in the *Archegosauridæ*, since the vertebræ are described as rhachitomous.

" 1036. *Capitosaurus* also occurs in the Bunter. The superiority of size of *Capitosaurus* over *Trematosaurus* renders it more probable that the former is the same as *Chirosaurus* (p. 1039).

" 1036, 1037. The alleged occurrence of *Mastodonsaurus giganteus* and *Metopias* in the Rhætic rests on insufficient evidence. The latter genus is stated to have been recorded from the Continental instead of the British Rhætic.

" 1041, bottom line, *dele* "and may not improbably be identical with *Chelotriton*."

" 1043, line 8 from top, *for* "each" *read* "hind," *and for* "pes" *read* "same." *Alytes* occurs in the Miocene of Sausan (*Rana Troscheli*). *Latonia* (p. 1044), according to Cope, is not allied to *Ceratophrys*, but belongs to the *Discoglossidæ;* it also occurs in the Sausan Miocene. The *Palæobatrachidæ* appear to connect the *Pelobatidæ* with the Aglossa, as represented by the *Dactylethridæ*, or *Xenopodidæ* as they should properly be called,—*Dactylethra* being a synonym of *Xenopus*.

" 1044. The name *Cystignathidæ* should be replaced by *Leptodactylidæ*, *Cystignathus* being a synonym.

" 1057, line 8 from top, *before* "characterised" *add* "typically."

" 1057, line 17 from top, *before* "African" *add* "typical."

" 1058-61. Additional characters of many of the genera are given in the Appendix.

" 1059, line 4 from top, *for* "divided" *read* "undivided."

" 1059, line 7 from top, *for* "single" *read* "double."

" 1108. *Ocadia* is distinct from *Palæochelys*. See Appendix.

" 1117, line 10 from bottom, the name "*Cyclanorbinæ*" may be substituted for "*Emydinæ*," since the latter is preoccupied.

" 1126. Since *Ichthyosaurus platyodon* differs from all other species of *Ichthyosaurus* by the smooth and carinated crowns of its teeth (fig. 1028), it appears, on the whole, advisable to regard it as the type of a distinct genus, for which the name *Temnodontosaurus* is proposed.

" 1139. *Rhaphiosaurus* proves to be founded upon part of a jaw of *Pachyrhizodus* (p. 993).

" 1176, line 2 from top, *for* "Kimeridgian" *read* "Portlandian."

" 1179, line 18 from top, *after* "species" *add* "of the former."

" 1264, fig. 1130. A is a skull of *Manis*, and not *Echidna*, as stated.

" 1372, lines 16, 17, from top, *for* "*Limnotherium*" *read* "*Limnohyus*."

PART III.

PALÆOZOOLOGY

VERTEBRATA

BY

R. LYDEKKER

PART III.

CHAPTER XLV.

SUB-KINGDOM VERTEBRATA.

General Characters.

The Vertebrata, or highest types of the entire animal kingdom, are distinguished as a whole from all the preceding sub-kingdoms (collectively designated as the Invertebrata) by the general presence of an internal skeleton, and more especially of a cylindrical longitudinal axis, termed the notochord, which is usually replaced in the adult by a series of cartilaginous or bony segments collectively constituting the *vertebral column*. This axis, or column, separates the smaller dorsal or neural tube of the body from the larger ventral or visceral (hæmal) tube: and the body itself, together with its appendages, is always symmetrical to this axis, and is never externally divided into segments. Limbs may be completely wanting, but when present they never exceed two pairs, and are always turned away from the dorsal or neural aspect of the body.

That the Vertebrata have been derived from the Invertebrata at an extremely early epoch of the earth's history is practically certain; and, although we are unable to point to the direct ancestors of the sub-kingdom, yet we have an inkling of this relationship exhibited by the presence of a notochordal structure in the earlier stages of the Ascidians, while there are also certain features in the organisation of the Annelids suggestive of their being allied to the primitive stock whence the Vertebrates took their origin. Since, however, it is probable that these primitive types were soft animals, it is unlikely that any light will be thrown on the origin of Vertebrates by means of Palæontology; and if the problem is ever to be solved it will be by the aid of Embryology.

Leaving then the origin of Vertebrates as an unsolved problem, in the solution of which the palæontologist can have but little share, we may proceed to a brief survey of the classification and chief structural features of the Vertebrate sub-kingdom, so far as they concern the palæontologist.

For this purpose the sub-kingdom may be divided into five classes[1]—viz., Pisces or Fishes, Amphibia or Amphibians, Reptilia or Reptiles, Aves or Birds, and Mammalia or Mammals—of which some of the more important features, from the point of view of the palæontologist, will be mentioned under these respective heads.

The first and second classes have been brigaded together by Professor Huxley under the name of Ichthyopsida, and the third and fourth as Sauropsida; and these terms will frequently be found convenient. Other writers, again, from the absence or presence of certain structures during the course of development, group together the two first classes as Anamniota (Anallantoidea, or Branchiata), and the remaining three as Amniota (Allantoidea, or Abranchiata).

Since the hard parts of Vertebrates are those with which alone the student of Palæontology usually has to deal, it will generally be unnecessary in this work to make any allusion to the soft parts of the body. With, regard, however, to these hard portions, it is advisable to give an extremely brief sketch of the more important elements of the Vertebrate *endo-* and *exoskeleton* for the benefit of those readers who are unacquainted with the elements of Comparative Osteology. It must, however, be distinctly understood by all who desire to practically study the history and structure of extinct Vertebrates, that it is absolutely essential they should have that thorough knowledge of the osteology of the recent members of the sub-kingdom which can only be gained by familiarity with actual specimens, accompanied by patient and laborious study of the numerous works on the subject. The following sketch is, indeed, merely sufficient to enable the reader to understand the meaning of the terms employed in the sequel; and throughout the Vertebrata the limits of this work will necessarily permit of only some of the more salient features of the skeleton of the various groups being mentioned. It may also be observed that those groups which have wholly disappeared, or of which the palæontological and evolutionary history is of especial interest, are more fully treated of than those more or less exclusively confined to the later or present epochs, and of which the history is fully recorded in those works to which the term "Natural History" is usually restricted. In the majority of instances, again, space does not permit of allusion to species; but

[1] A sixth class—Leptocardii—is formed for the reception of the Lancelet (*Amphioxus*), with which the palæontologist has, unfortunately, no concern, as its past history is a blank.

in the case of very large genera, where the species differ considerably in essential characters, attention is in some instances directed to the more important specific types. The student must not, moreover, expect to find that every known genus of fossil Vertebrates, or even every family, is mentioned in the following chapters, of which the object is to enable him to gain a fair general knowledge of the past history, distribution, and leading structural features of the best known groups of the various classes.

Commencing with the outer skeleton or *exoskeleton* it may be observed that, as a rule, the palæontologist has but little to do with structures developed in the *epidermis*, or layer overlying the true skin or *dermis*, since these generally perish during the process of petrifaction. The scales of Lizards belong, however, to this layer, and their impressions are in some instances preserved; while in the Chelonia the boundaries of the horny shields, covering the bony shell, are in some instances the most important characters by which fossil specimens can be determined. Occasionally, again, as in the Solenhofen *Archæopteryx*, the feathers of Birds have left their impression in rocks of which the material is of a fine-grained structure; while still more rarely, as in the bony covering of some Glyptodonts, pits from which hairs or bristles once grew are preserved in a fossil state.

The *dermal* exoskeletal structures are of considerably more importance from a palæontological point of view; and it should be observed that in nearly all the classes there appears to have been a gradual tendency to the disappearance of the bony elements of this skeleton in the higher forms, this being especially marked in the case of Fishes. In the latter class the scales of all types, of which fuller mention will be made in the sequel, belong to the dermis, and in some forms there may be a complete dermal armour formed of imbricating scutes, as in *Callichthys* among the Siluroids, or, as in the Coffer-fishes (*Ostracion*), consisting of calcified scutes with their edges in apposition. Apparently the most primitive type of dermal armour in this class consists of small denticules supported on bony plates, and it has been found that such denticules are absolutely homologous with true teeth, of which we shall speak presently. The bony *fin-rays*[1] and *fin-spines* of Fishes are another development of the dermal skeleton, which will be noticed under the head of that class; although it may be observed here that many of the latter are closely allied in structure to teeth. Again, the dermal skeleton in many extinct Amphibians and Reptiles takes the form of a more or less complete armour, either on the ventral or the dorsal, and not unfrequently on both aspects of the body, con-

[1] These dermal fin-rays must not be confounded with the radial cartilages of the endoskeleton.

structed of solid bony *scutes*, which may imbricate or overlap one another, like the tiles on a roof, or may be firmly united at their edges by sutural union. Such an armour may also develop enormous bony spines, often attached to the skin by an expanded base which represents the scutes. In the latter class, again, the bony shells of the Testudinate Chelonia are formed partly of dermal elements, blended with others belonging to the endoskeleton to form a continuous whole; while in the Athecate division of the same order the whole of the protective armour is of dermal origin.

The so-called membrane bones of the skull, and the clavicular portions of the pectoral girdle, are likewise of dermal origin, and therefore properly belong to the exoskeleton; but their intimate connection with cartilage bones renders it more convenient to consider them with the endoskeleton.

Teeth, as belonging to the list of dermal structures, may be conveniently noticed here; and the importance of these organs to the palæontologist can scarcely be overrated, since from their extreme density they are more often preserved in a perfect condition than most other parts of the skeleton, and thus frequently form the only safe guide to the affinities of an extinct type. Teeth are composed of two or more earthy constituents, varying in their structure, and the amount of animal matter contained in them. The most important element is that known as *dentine* (fig. 813, *d*), which forms the greater portion of the body of most teeth, and consists structurally of extremely minute tubes, cells, and earthy particles. Some dentine is devoid of blood-vessels; but in other cases it is permeated by the latter, when it is known as *vascular*, or *vaso-dentine;* and both these structures may exist in a single tooth. In young teeth (fig. 813) the centre of the dentine mass is occupied by the vascular *pulp-cavity* (*pc*), which is open at the base; but in the adult this cavity is often totally obliterated, by the formation of what is known as *osteo-dentine*, which is a kind of vascular dentine passing imperceptibly into the structure of true bone. The second primary constituent is the *enamel* (*c*), which, when present, immediately overlies the dentine of the *crown*, or exposed portion of the tooth, and is the hardest known animal substance; it is composed of extremely minute prismatic fibres, generally running at right angles to the outer surface of the tooth. This substance is the least constant element in teeth, although it is very generally present in those of Mammals; among the Reptiles it is entirely wanting in the Ophidian Squamata, but is present in the Crocodilia. The

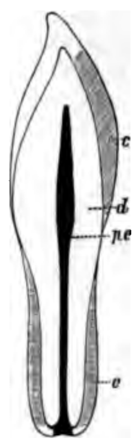


Fig. 813.—Diagrammatic vertical section of a tooth. *e*, Cement; *d*, Dentine; *c*, Enamel; *pc*, Pulp-cavity.

third constituent, usually known as *cement* (fig. 813, *e*), but occasionally as *crusta petrosa*, is the most external of the three: in some instances, as in fig. 813, it is confined to the *root*, or embedded portion of the tooth, where it consequently comes into immediate contact with the dentine; but in other cases it is found overlying the enamel of the crown, and in others again, where the enamel is wanting, it forms the main covering of the crown, as in the teeth of the Edentate Mammals. The cement is always traversed by vascular canals; and its structure is very similar to that of bone, although only occasionally presenting all the peculiarities of the latter.

True teeth are generally confined to the mouth and pharynx, but they may be situated on many of the bones of the former, and their mode of attachment varies from a simple anchylosis to the underlying bone, to implantation in distinct sockets. The simplest forms of teeth are small granular bodies, like the minute ossifications already mentioned as occurring in the skin of certain Fishes; while those of the most complex structure are to be found in certain Fishes (*Dendrodus*), in the Labyrinthodont Amphibians, and among Mammals in the Edentate genus *Orycteropus* and many Rodents and Ungulates. Except in forms where all are alike, as a general rule the teeth at the anterior extremity of the jaws are more or less simple, while there is a gradual increase in their complexity towards the opposite end, and in most cases the lower teeth are narrower and more elongated in an antero-posterior direction than the upper ones.

The importance of teeth to the palæontologist as a means of determining the affinities of fossil forms has been already mentioned; but in many cases their evidence must be supplemented either by that of other remains, or of the geological horizon whence they were obtained; since otherwise serious error may result. Thus, the teeth of the Dinosaurian *Megalosaurus* present a strong resemblance to some of those of the Mammalian *Machærodus;* while the front teeth of some Sparoid Fish approximate to those of the Primates; and the lower hinder teeth of the Kangaroos, of the Dinothere among the Proboscidea, and of the Tapir-like animals in the Perissodactyla, are all singularly alike in form. Another fertile source of error to be guarded against is the great difference in the form of the teeth from different regions of the mouth.

For the microscopic structure of teeth and their mode of development, the student must refer to other works; but a large number of the more important types of dental structure will be found noticed in the course of the following pages.

By far the greater number of adult Vertebrates possess a solid inner, or *endoskeleton*, composed of bone (into the nature of which it will be unnecessary to enter here); but in others this skeleto remains cartilaginous throughout life, or, as in many Sharks, ha solid structures formed by calcificatior in the cartilage, which are quite distin from true bone. This endoskeleton ma be divided into an *axial portion*, or th of the head, trunk, and tail; and an *a pendicular portion* supporting the limb the relations of the two being shown i fig. 814. The anterior part of the axi skeleton is formed by the *skull* (of whic we shall speak later); and this is su ceeded posteriorly by the *vertebral colum* typically composed of a number of se ments, known as *vertebræ*, placed in th middle line of the dorsal side of th body, and continuing from the head t the extremity of the tail. This column is developed round a rod-like axis known as the *notochord*. In certain of the lower forms the latter may persist throughout life, and may either simply have a fibrous or cartilaginous sheath, or may have calcifications, or cartilages, in either the dorsal or ventral po tion; and there is a complete transitio from such a primitive type of colum to that of the more specialised types i which the vertebræ are fully ossifie There is an enormous amount of variatio in the structure of the vertebræ of diffe ent groups, and even in the differen regions of the body of a single anima but there is one general plan pervading them all. Thus a typic vertebra (fig. 815) consists of a basal portion, or *centrum*, whic may be either disk-like or more or less elongated. Its posterio

Fig. 814.—Under surface of a Labyrinthodont Amphibian (*Seeleya*), with the dermal armour removed from the left side in order to show the endoskeleton. Greatly enlarged. (After Fritsch.)

Fig. 815.—Left lateral vie of an imperfect amphicœlo dorsal vertebra of a Dicynodo Reptile. *sp*, Neural spi (broken); *pz*, Prezygapoph sis; *pt.z*, Postzygapophysi *tp*, Transverse process (broken *cp*, *Rib*-facet on the centrum *b*, *b'*, Muscular ridges.

and anterior surfaces, by which (with the intervention of cartilages) it articulates with the adjacent centra, may be nearly flat or concave, when it is said to be *amphicœlous* (fig. 815); or its anterior surface may be more or less hollow, and the posterior convex (fig. 816), when it is termed *procœlous;* or, lastly, the reverse of the latter arrangement may obtain, when the centrum is termed *opisthocœlous;* an example of the latter structure being shown in the vertebra of *Calamospondylus* given in the sequel (fig. 1071). Immediately above the centrum is the aperture of the channel for the reception of the spinal cord, known as the *neural canal* (fig. 816); this canal being enclosed laterally and superiorly by the *neural arches*, which are surmounted by the *neural spine* (figs. 815, 816). The lateral portions of this arch are termed the *pedicles* (fig. 817, *n*), and the parts connecting the latter with the spine the *laminæ*. The arch, it should be observed, always ossifies separately from the centrum, and the line of junction between the two when, as in many Rep-

Fig. 816.—Anterior (B) and posterior (C) views of a procœlous dorsal vertebra of a Lacertian Reptile (*Varanus*). The part above B and C is the centrum; the aperture the neural canal, above and round which are the neural arches, surmounted by the neural spine; the oblique facets are the zygapophyses, and the lateral prominences the transverse processes, which are here very short.

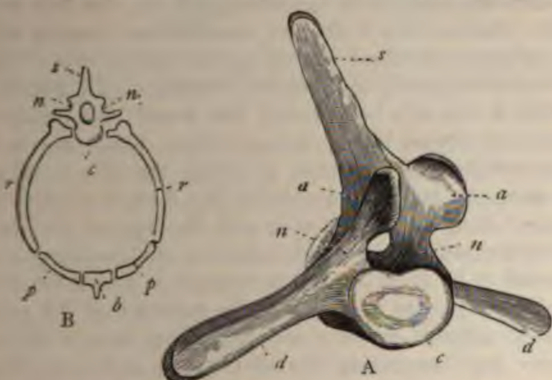


Fig. 817.—A, Oblique anterior view of the lumbar vertebra of a Whale. B, Diagrammatic transverse section of the bones of the thoracic region of a Mammal. Greatly reduced. *a*, Prezygapophyses; *b*, Sternum; *c*, Centrum; *d*, Transverse process; *n*, Pedicle of arch; *p*, Sternal rib; *r*, Rib; *s*, Neural spine. (After Owen.)

tiles, they remain distinct, is known as the *neuro-central suture.* The neural arch bears a pair of processes, or facets, at either extremity for articulation with the adjacent vertebræ; those at the anterior extremity (fig. 816, B) being known as *prezygapophyses*, and looking inwards and upwards; while those at the other extremity (fig. 816, C) are termed *postzygapophyses*, and look downwards and outwards.[1] Besides these processes for mutual articulation, there are other processes on many vertebræ; the most constant being the *transverse processes*, or *diapophyses*, which may be very short as in fig. 816, or greatly elongated as in fig. 817, A, *d*. These transverse processes may arise either from the arch or from the centrum, and in the trunk frequently serve for the main attachment of the *ribs* (fig. 817, B). In fig. 816 we have an example of a vertebra with very short transverse processes placed mainly on the centrum, while in the vertebra of *Iguanodon*, figured in the sequel (fig. 1058), we see very large transverse processes arising solely from the arch.

The sides of the centrum in the anterior region of the body frequently carry other articular processes for the ribs, which may be termed rib or costal facets (fig. 815, *cp*), or *parapophyses*. Again, the inferior or hæmal surface of a vertebra may bear a *hæmal spine*—the term hæmal being applied to the inferior aspect on account of its being directed towards the heart and large blood-vessels. Each vertebral centrum carries its own arch; but between the true centra of the Ichthyopsida there may be intercalated centra-like bodies, carrying no arches, and termed *intercentra*. Rudiments of such intercentra occur in the so-called *wedge-bones* or *hæmapophyses*, found between the lower borders of the centra in certain Reptiles, and more especially between the first and second vertebræ. Further, the Y-shaped *chevron-bones*, usually articulating between adjacent vertebral centra in the tail of many Vertebrates, are also morphologically intercentral elements. In Fishes the vertebral column can only be divided into *trunk* and *caudal* regions; but in the majority of higher forms further divisions can be made. Thus the vertebræ of the neck, in which the ribs never articulate with the sternum, are termed *cervical* (fig. 818, *c*); the first of this series being designated the *atlas*, and the second the *axis*. It is further remarkable that in most instances the centrum of the atlas is not joined to its arch, but either remains as a distinct element, or becomes anchylosed to the front of the centrum of the axis to form the so-called *odontoid process*; and it appears that in the latter case the inferior bar connecting the two lateral arches of the atlas is really the remnant of the first intercentrum. It is, moreover, probable that this separation of the component elements of the atlas should be regarded as a retention of the primitive feature obtaining in the vertebral column of many extinct Fishes and Amphibians, where, as will be noticed below, the whole of the vertebræ are thus disintegrated. Finally, it has been suggested that certain bony

[1] These are well seen in the vertebra of *Calamospondylus* above mentioned.

centra; but by the disappearance of the latter they have frequentl become transferred to the centra or their appendages, although ir other cases their original derivation is indicated by their articulatior at the junction of two vertebræ. Very generally ribs articulate witl the vertebral column by two distinct heads, which is probably th original primitive type of structure. In these cases the anterior o lower head is termed the *capitular*, and articulates with the rib facet or parapophysis on the vertebral centrum (fig. 815, *cp*); whil the posterior or upper head is known as the *tubercular*, and in th dorsal vertebræ articulates with the transverse process or diapophysi of the arch. In the dorsal ribs th two heads may, however, coalesce and articulate with a facet on th centrum, or with a longer or shorte transverse process on the arch. Frequently, moreover, while the anterio dorsal ribs have double heads, th posterior ones have but a single hea articulating with the transverse pro cess. In the caudal region of man Reptiles true ribs articulate with th upper part of the centrum, and e cept as being separate, are indi tinguishable from the caudal tran verse processes of many Mammal such as the Cetacea (fig. 817 Cervical ribs are present in mo Reptiles, and usually articulate b two heads to the vertebræ — th upper head joining a facet, generall placed on the arch, correspondin to the transverse process of the dorsal vertebræ, and the lower on articulating to another facet on the centrum. Very rarely in Rep tiles these cervical ribs may be completely anchylosed to the ve tebræ, as in the vertebra of *Calamospondylus*, figured in the sequ (fig. 1071); and this suggests that at least a portion of the so-calle transverse processes of the cervical vertebræ of Mammals, whic arise from the vertebræ by double pedicles, really correspond t cervical ribs. In the Sauropterygia both heads of the cervic ribs articulate with the centrum.

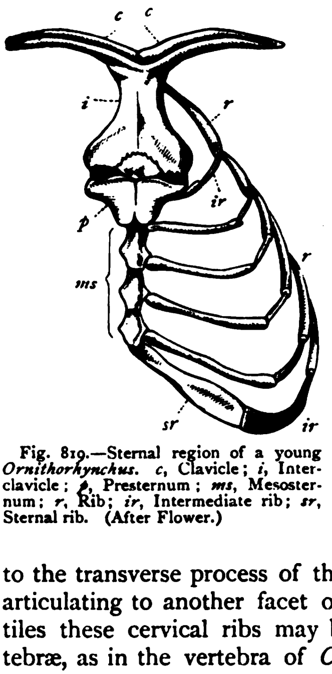


Fig. 819.—Sternal region of a young *Ornithorhynchus*. *c*, Clavicle; *i*, Interclavicle; *p*, Presternum; *ms*, Mesosternum; *r*, Rib; *ir*, Intermediate rib; *sr*, Sternal rib. (After Flower.)

When a sternum is present the distal ends of the dorsal ribs ar generally unossified, and are sometimes termed ***intermediate ri*** (*ir*, fig. 819); and these unossified elements unite distally with th sternal ribs (*sr*), which in their turn join the sternum (fig. 817, B, *b* Further, among the Sauropsida lateral ossifications may be develope on the ribs, termed *uncinate processes*, of which the position is shown in the figure of the skeleton of the Eagle given below (fig. 1106).

The breast-bone or *sternum* (figs. 817, 819) is usually composed of a median series of bones or cartilages on the ventral aspect of the body, which is divisible in the higher groups into an anterior *presternum*, usually consisting of a single ossification; and of a series of *mesosternal* elements, followed posteriorly by the *xiphisternum*. In many Sauropsida the sternal bones have long lateral processes; and the ossifications in this class may consist of a pair of bones united by cartilage.

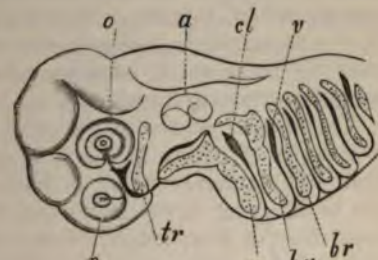


Fig. 820.—Left lateral view of the skull of an embryo Dog-fish. *tr*, Left trabecula; *n*, *o*, *a*, Nasal, orbital, and auditory capsules; *m*, *hy*, *br*, Mandibular, hyoid, and branchial arches; *cl*, *v*, Hyomandibular and first branchial clefts. (After Parker.)

The *skull*, or anterior termination of the axial skeleton, now claims our attention, but the description of this important and difficult part must be of the briefest. The researches of embryologists have shown that the skull is only a special modification of the primitive elements from which the rest of the axial skeleton were formed, although it does not consist, as was once thought, of a series of modified vertebræ. The skull is divisible into a dorsal, or *cranial*, and a ventral, or *visceral*, portion; the former, originating from a series of primitive segments (*somites*), encloses the brain-cavity; while the latter, which has a segmentation of distinct and later origin, is primitively connected with the function of respiration.

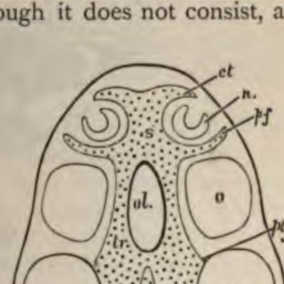


Fig. 821. — Upper view of a later embryo. *ct*, Cornu of trabeculæ; *pf* and *ptf*, Preorbital and postorbital processes of do.; *s*, Ethmonasal septum; *b*, Basilar plate; *no*, Notochord; *ol*, Olfactory foramen. Other letters as in fig. 820.

The earliest commencement of the primitive cartilaginous cranium occurs in the formation of a pair of rod-like *trabeculæ* (fig. 820), lying at the base of the brain, of which the posterior *parachordal* parts embrace the extremity of the notochord (fig. 821). These parachordals soon unite to form a *basilar plate* supporting the brain (fig. 821); while the anterior *prochordal* parts unite in front to enclose a space (*ibid.*, *ol*) for the passage of the olfactory nerves, the united portion forming the *ethmonasal septum* (*ibid.*, *s*). By th approximation of the basilar plate to the *nasal*, *orbital*, and *auditor capsules*, these three distinct sense-regions become differentiated i the cranium; and while the first and third become enclosed i cartilage, the lateral borders of the basilar plate, in some instance grow upwards to enclose the brain in a complete cartilaginou capsule, which in certain Sharks (fig. 822) persists throughout lif In the higher forms, however, the cartilage does not extend upward over the brain, which becomes roofed in by bone formed directl from the overlying membrane.

The *visceral portion* of the skull is formed by cartilages arrange in a series of *arches* in the walls of the throat (fig. 820). In th Ichthyopsida there may be as many as nine of these *visceral arche* but in the other three classes they become reduced in number to a most three or four, which are also functionally modified. The fir arch (fig. 820, *m*) supports in all cases the walls of the mouth, an is accordingly called the *mandibular* arch; the second is termed th *hyoid*; while the remaining ones, which persist only in the adults Fishes as supports of the gills or *branchiæ*, are termed *branchia* It should further be observed that these arches are separated fro

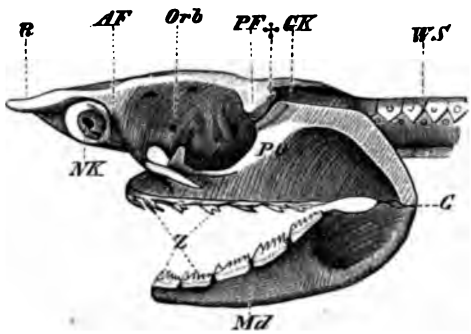


Fig. 822.—Left lateral view of the cartilaginous skull ot a Shark (*Notidanus*), greatly reduce *R*, Rostrum; *AF*, *PF*, Pre- and post-orbital processes; *Orb*, Orbit; *NK*, Nasal capsule; † Articulation of palatopterygoid (*PQ*); *G*, Articulation of Meckel's cartilage (*Md*); *Z*, Teeth *WS*, Vertebral column. (After Wiedersheim.)

one another in the embryo by a series of *visceral clefts* (fig. 820), c which the respiratory apertures of Sharks are remnants. The *man dibular arch* becomes divided into segments, consisting of a sho proximal portion known as the *quadrate*, which very generally form the main support of the lower jaw; and a long distal portion know as *Meckel's cartilage*, around which the *mandible*, or lower jaw, is sub sequently formed in those forms which develop membrane bones, bu which in the Sharks persists throughout life as the functional lower ja (fig. 820). The quadrate gives off an anterior *palatopterygoid* (*palatoquadrate*) bar, which in Sharks (fig. 822) persists to form a kind of false upper jaw. The hyoid arch, which is close to the mandibular, and which in Fishes may also take a share in the support of the mandible, is likewise segmented; the most important elements in the latter class being the *hyomandibular* and the *symplectic*, which are shown in an ossified condition in fig. 823, *hm*, *sy*. As already mentioned, in Sharks the primitive cartilaginous skull is complete, and persists in this condition throughout life; but in the great majority of Vertebrates the progress of chondrification is arrested,

Fig. 823.—Left lateral view of the suspensorial and mandibular region of the skull of a Salmon. *hm*, Hyomandibular; *mt*, Metapterygoid; *qu*, Quadrate; *sy*, Symplectic; *po*, Preopercular; *io*, Interopercular; *so*, Subopercular; *o*, Opercular; *ar*, Articular; *d*, Dentary. (After Parker.)

and the skull becomes more or less completely covered in with a series of ossifications developed in the membrane overlying the brain, while the cartilaginous foundation itself is likewise converted into bone. Bones derived from these two totally distinct sources amalgamate in the adult in such a manner as to afford no clue to their dual origins. Following a modification of an arrangement adopted by Professor Weinsheimer, the more important bones of the cranium may be enumerated as follows: the relative position of most of them being shown in figs. 824 and 825.[1] The cartilage bones comprise the *basioccipital*, *basisphenoid*, and *presphenoid*, which are median ossifications (not shown in the two figures) lying in this order (from the posterior extremity) on the inferior aspect of the cranium, and the first forming the floor of the *foramen magnum*, or aperture by which the spinal cord enters the cranium, and the three being collectively known as the *basi-cranial axis*. On

[1] In the sequel the figures of the skulls of many reptiles, and more especially those of *Ichthyosaurus* and *Nothosaurus*, show the general relations of the bones of the skull to advantage.

the sides of the basioccipital we have the two *exoccipitals*, forming the lateral boundaries of the foramen magnum, and either alone or in conjunction with the basioccipital, the single or double *occipital condyles*, by which in the higher forms the cranium articulates with the atlas vertebra. The bony auditory capsule is composed typically of the *proötic*, *epiotic*, and *opisthotic*,[1] to which in Teleostean Fishes must be added the *sphenotic* and *pterotic;* but, as will be noticed below, some of these bones may unite, when they receive a distinct name. The *alisphenoids* and *orbitosphenoids* are paired bones developed in the trabecular region; while the single *ethmoid* and the paired *turbinals* occur in the nasal region. The position of the *quadrate* has been already mentioned. Among investing or

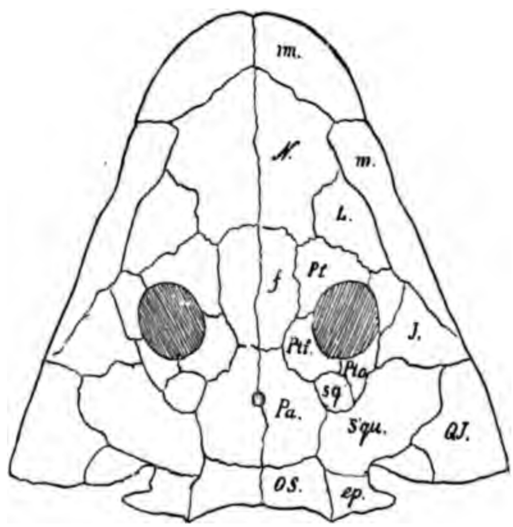


Fig. 824.—Upper surface of the cranium of a Labyrinthodont Amphibian (*Nyrania*), one-half natural size. *im*, Premaxilla; *m*, Maxilla; *N*, Nasal; *L*, Lachrymal; *f*, Frontal; *Pf*, Prefrontal; *J*, Jugal; *QJ*, Quadratojugal; *ep*, Opisthotic; *OS*, Supraoccipital; *Sq*, Squamosal; *Squ*, Supratemporal; *Pa*, Parietal; *Ptf*, Postfrontal; *Pto*, Postorbital. The quadrate would come below *QJ*; the large vacuities are the orbits; and the small aperture in *Pa* the parietal foramen. (After Fritsch.)

membrane bones, which are of a more or less splint-like structure, we have the following paired ossifications, reckoning from before backwards, on the upper surface—viz., *premaxilla* (*im*), *maxilla* (*m*), *nasal* (*N*), *lachrymal* (*L*), *frontal* (*f*), *prefrontal* (*Pf*), *postfrontal* (*Ptf*), *postorbital* (*Pto*), *parietal* (*Pa*), *supratemporal* (*Squ*), and *squamosal* (*Sq*). In some Dinosaurian Reptiles, as *Stegosaurus*, there appears to be a distinct bone above the orbit, which connects the pre- and postfrontal, and may be termed the supraorbital. The

[1] Shown in the skull of *Testudo*, figured in the sequel, fig. 1017 A.

supraoccipital (*OS*), which, although double in the figured skull, is usually a single bone, appears to be developed inferiorly from cartilage and superiorly from membrane; it usually forms the upper border of the foramen magnum, and is not unfrequently produced posteriorly into a long spine. On the lateral aspect of the cranium are placed the *jugal* (*J*), and *quadratojugal* (*QJ*), which connect the quadrate with the maxilla; while inferiorly (fig. 825) we may have a median splint-like *parasphenoid* (*Ps*), and always a single or

Fig. 825.—Under or palatal view of the cranium represented in fig. 824. *V*, Vomer; *P*, Palatine; *Pt*, Pterygoid; *QJ*, Quadratojugal; *Ps*, Parasphenoid. (After Fritsch.)

paired *vomer* (*V*), and the paired pterygoids (*Pt*), and palatines (*P*). The two latter, it may be observed, are developed upon the primitive palatopterygoid bar; while the parasphenoid, when present, underlies the basicranial axis, and if largely developed, as in Teleostean fishes and Amphibia (fig. 825), seems to take the place of the basi- and presphenoid.

In the cranium of which an upper view is given in fig. 824 the whole of the region behind the orbits is completely roofed over by bone, so that a secondary roof is thus formed above the roof of the much smaller brain-case which lies within. In most Reptiles there are, however, vacuities or fossæ in this outer roof (as in fig. 826), although in the Turtles and the Ichthyosaurs (fig. 1024) this roof persists. In fig. 826 the upper-lateral vacuity is termed the *supra-temporal fossa*, and is bounded below by the *superior temporal* (or *squamoso*-prefrontal) *arcade* formed by the squamosal, postorbital, and postfrontal; while the lower or *infratemporal fossa* is bounded superiorly by the last-named arcade, and below by an *inferior temporal* (or *quadrato-maxillary*) *arcade*, formed in most Reptiles (fig. 826) by the quadrate, quadratojugal, jugal, and maxilla. In the Mammalia (where it is usually termed the *zygomatic arch*) we find, however, a single arcade formed by the squamosal, jugal, and maxilla, and a similar arcade, but with the apparent absence of the jugal, occurs in many of the Anomodont Reptiles. This may be termed the *squamoso-maxillary arcade*. In many Sauropsida, when a postorbital or postfrontal is developed, these two arcades are

Fig. 826.—Right lateral aspect of the cranium of *Sphenodon punctatus*. The lower vacuity on the left is the infratemporal fossa, bounded below by the inferior, and above by the superior temporal arcade; the vacuity above the latter being the supratemporal fossa. The posterior border of the latter fossa is formed by the parieto-squamosal bar. The quadrate is on the left lower corner of the figure. (After Günther.)

usually connected behind the orbit by a process from the former articulating with another from the jugal, and thus forming a bar or arch which may be termed the *postorbital bar* or arch. Similarly another bar at the posterior extremity of the supratemporal fossa is formed by the quadratojugal (or quadrate), squamosal (the supratemporal of fig. 824 being absent), and parietal, and may be termed the *posttemporal*, or *parieto-squamosal bar*, or arch. A third fossa behind this bar is termed the *posttemporal fossa*. It will be observed that these numerous vacuities expose to view the brain-case lying within these arches or bars; and there seems to have been a gradual tendency to open up the completely roofed skull of the Labyrinthodont Amphibia till in the Mammals we find, as already mentioned, the squamoso-maxillary, or zygomatic arcade, and often a postorbital bar, as the sole remnants of this primitive secondary roof.

It will not be necessary to mention the various neural and vascular foramina of the cranium, but it must be observed that on the upper aspect there are paired apertures for the *orbits* (fig. 826), and either paired or single ones for the *nares* (*ibid.*); while between these apertures there may be the paired *preorbital vacuities*, which are shown in the figure of the skull of *Phytosaurus* among the Crocodilia. Mention must also be made of the *parietal foramen* (fig. 824), which is a vacuity occurring in the parietals of many Reptiles and Amphibians. In several living forms this foramen immediately overlies an aborted median eye embedded in the subjacent tissues, and totally functionless; but it is not improbable that in the Labyrinthodonts and other early forms this eye served the purposes of vision. As the attention of the palæontologist is often directed to them, we must also observe that the *Eustachian tubes* are canals connecting the internal ear with the pharynx or gullet. Apart from certain minor ossifications which will be incidentally noticed in the sequel, we must also call attention to the *periotic* and *tympanic* of Mammals, since among the Cetacea these bones are of great importance to the palæontologist. Both these bones are connected with the internal ear, the first resulting from the coalescence of the proötic, epiotic, and opisthotic of the lower forms, and containing the *cochlea* of the ear; while the latter is formed by ossification in the tissues around the tympanic membrane, and also occurs in some Birds. Finally, the term *tympanic ring* is a convenient one to apply to the bones surrounding the external ear of Reptiles, and especially the Chelonia.

In regard to the *mandible*, or lower jaw, which we have already stated to be formed by ossifications in the region of Meckel's cartilage, each half, or *ramus* (fig. 827), in the Sauropsida and Am-

Fig. 827.—Inner view of the left ramus of the mandible of *Crocodilus*. *sy*, Symphysis; *d*, Dentary; *s*, Splenial; *co*, Coronoid; *an*, Angular; *su*, Surangular; *ar*, Articular. Reduced. (After Cuvier.)

phibia consists of the following five ossifications formed in membrane—viz., *dentary* (*d*), *splenial* (*s*), *coronoid* (*co*), *angular* (*an*), and *surangular* (*su*). These unite with the *articular* (*ar*), formed from Meckel's cartilage, which articulates by a *glenoid cavity* with the quadrate. In Mammals, however, there is but a single membranous ossification in each ramus, which posteriorly articulates by a rounded *condyle* with the squamosal bone of the cranium, there being apparently no articular ossification, and no distinct quadrate in connection with the mandible.[1] In the Sauropsida the quadrate articulates

[1] See the introductory chapter on the Mammalia (Chapter lvii.)

directly with the periotic region; but in the greater number of Fishes the mandible, as already mentioned, is connected with the cranium by means of the hyomandibular suspensorium (fig. 823).

Having now noticed the leading features of the axial, we may proceed to an equally brief survey of those of the appendicular skeleton. In all the higher Vertebrates the limbs are divided into three sections — viz., in the *pectoral* or fore *limb* the *arm*, *fore-arm*, and the *hand* or *manus*; and in the *pelvic* or hinder *limb* the *thigh*, *leg*, and the *foot* or *pes*. The first segment has a single bone—the *humerus* of the arm, and the *femur* of the thigh (fig. 828); the second has two parallel bones—the *radius* and *ulna* in the fore-arm, and the *tibia* and *fibula* in the leg (fig. 828); while the third segment contains a number of bones arranged in not more than five longitudinal rows (figs. 828, 829), with the exception of the Ichthyopterygian Reptiles. The bones of the manus and pes are again divisible into three sections—viz., proximally the *carpus* or wrist in the manus (fig. 829), and the *tarsus* or ancle in the pes; mesially the *metapodium*, or *metacarpus* of the manus (fig. 829), and the *metatarsus* of the pes (fig. 828); and distally the phalangeals (figs. 828, 829) of the digits. With the exception of the Ichthyopterygia, where the normal digits appear to have divided, in all known forms the number of functional digits does not exceed five; and these are enumerated consecutively from the radial or tibial side, so that the *pollex* or thumb of the manus, and the *hallux* or great toe of the pes are always termed the first, and the little finger and toe the fifth digits. Except in the hallux there are usually not less than three phalangeals in each digit of the pes, but their number may be reduced in the manus. The bones of the metapodium correspond in number with the digits, and consist of a single transverse row.

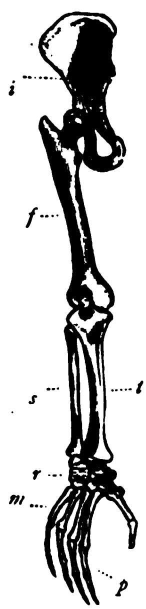


Fig. 828. — Dorsal aspect of right innominate and pelvic limb of the Chimpanzee (*Troglodytes*), reduced. *i*, Innominate; *f*, Femur; *t*, Tibia; *s*, Fibula; *r*, Tarsus; *m*, Metatarsus; *p*, Phalangeals. (After Owen.)

Although, as we have stated, the number of digits in the higher Vertebrates is typically five, yet there appears to be considerable evidence that the number was originally seven. Thus in many pentedactylate Mammals, and also in some Reptiles and Amphibians, there is found on the radial or preaxial border of the carpus or tarsus a small ossification which Dr Bardeleben terms the *prepollex*, or *prehallux*, and regards as the representative of an additional radial digit. Similarly the *pisiform* bone of the carpus, which occurs on the ulnar or postaxial border, and in Mammals is usually described as one of the so-called sesamoid bones, is looked upon by the same authority as the representative of a seventh digit on the ulnar side.

It is probable that the carpus and tarsus were originally formed upon a common type, which persists in a more or less unaltered condition in certain Amphibia and Reptilia (fig. 829). In such a generalised type there is a distal row of five carpalia (fig. 829), or tarsalia, articulating with the metapodials. This is preceded proximally by another row, consisting of an *intermedium*, flanked in the manus by a *radiale* and *ulnare*, and in the pes by a *tibiale* and *fibulare*, respectively articulating with the two epipodial bones of the fore-arm (radius and ulna) or leg (tibia and fibula). The middle space between these two transverse rows of bones is occupied by one *centrale*, or occasionally by several *centralia*. Modifications from this type are caused by the suppression or coalescence of some of these elements. All the carpals and tarsals in the Mammalia have received distinct names, which will be noticed under the head of that class; but it may be observed here that the higher Reptiles and Birds agree with the former in having two bones in the proximal row of the tarsus —viz., the *calcaneum* on the fibular, and the *astragalus* on the tibial side.

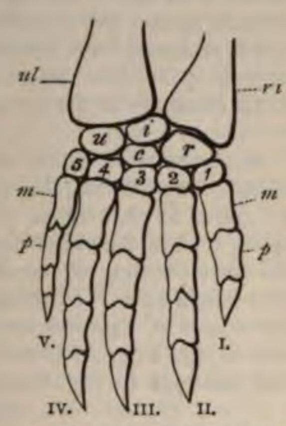


Fig. 829.—Dorsal aspect of the right manus of a Chelonian Reptile (*Chelydra*). *ra*, Radius; *ul*, Ulna; *r*, *i*, *u*, Radiale, ulnare, and intermedium; *c*, Centrale; 1—5, Carpalia; *m*, Metacarpals; *p*, Proximal phalangeals; I.—V., Terminal do., I. being the pollex. (After Gegenbaur.)

The protuberances for muscular attachment at the proximal extremity of the humerus are termed *tuberosities*, while those of the femur are known as *trochanters*. The latter bone in the Sauropsida may also have an *inner trochanter* on its shaft for the attachment of the *femoro-caudal* muscle; while in the Mammalia there may be a *third trochanter* for that of the gluteus maximus, as is shown in the femur of *Rhinoceros* represented in fig. 1226. Both the humerus and femur have more or less distinct *condyles* at the lower extremity for the articulation of the bones of the fore-arm and leg—those of the humerus being often termed *trochleæ*. Above the condyles or trochleæ the humerus has projecting *epicondyles* on either side; and there is frequently a foramen situated above either the outer or inner epicondyle. When placed above the outer or radial epicondyle this foramen is termed *ectepicondylar*, and when above the inner or ulnar epicondyle *entepicondylar*. The proximal extremity of the ulna is often produced into an *olecranon* (fig. 1300), which projects behind the end of the humerus. The distal extremity of the tibia in certain Sauropsida develops from its anterior aspect a ridge or process known as the *cnemial crest;* while the *deltoid crest* or ridge is a prominence situated below the head of the humerus on the radial side, to which the attention of the palæontologist is not unfrequently directed. Finally, the *patella* is a so-called sesamoid bone developed in the tendon of a muscle passing over the pulley-like surface or trochlea on the anterior aspect of the distal extremity of the femur.

Since the limbs of Fishes differ considerably from the higher type of structure noticed above, their consideration may be deferred till we come to that class. Before, however, leaving the subject of limbs, it should be observed that it is often convenient to allude to the corresponding or homologous sides of the fore and hind limbs by a single term. If, then, we imagine the limbs extended more or less nearly at right angles to the axis of the body (as on the left side of fig. 814), with the palm of the hand and the sole of the foot directed to the front or ventral aspect, the middle digit of each limb will be *axial*, when the pollex and radius of the pectoral, and the homologous hallux and tibia of the pelvic limb, will be obviously *preaxial;* while the fifth digit of each limb, together with the ulna and the fibula, will be *postaxial*. The whole of the radial and tibial sides of the limbs will accordingly be known as the *preaxial*, and the ulnar and fibular as the *postaxial border*.

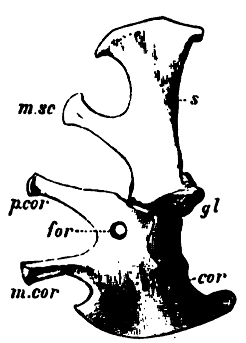


Fig. 830.—Lateral aspect of the cartilage bones of the left side of the pectoral girdle of a Lizard (*Iguana*). *s*, Scapula; *m.sc*, Mesoscapular process of do.; *cor*, Coracoid; *p.cor*, Precoracoidal process of do.; *m.cor*, Mesocoracoidal process of do.; *for*, Foramen of do.; *gl*, Glenoid cavity.

The remaining parts of the skeleton comprise the *pectoral* and *pelvic girdles*, by which the corresponding limbs are respectively connected with the trunk, and of which the relative positions are shown in fig. 818. The pectoral arch is never connected by means of ribs with the vertebræ, and primitively consists of three main bones developed in cartilage. On the dorsal aspect of the body we have the upper bone or *scapula* (fig. 830, *s*); while on the ventral side there are two parallel bones (fig. 974), the anterior of which is termed he *precoracoid* (*cl*), and the posterior the *coracoid* (*co*). At the unction of these three bones there is a cavity for the articulation of the head of the humerus termed the *glenoid cavity*. Such is the primitive condition of this girdle; but in Reptiles the precoracoid very rarely exists as a separate ossification, although it does so among the Anomodonts, where, at least in the young, it forms a large plate, uniting below to the upper edge of the coracoid, and entering into the formation of the glenoid cavity.[1] In all other cases it is, however, completely fused either with the scapula or the coracoid. Thus in the Chelonia (fig. 1008) the precoracoid retains its primitive form and condition of a transverse bar, which is, however, completely fused with the scapula. In the Lizards, on the other hand, this bone has united with the coracoid, of which it forms the precoracoidal process (fig. 830, *p.cor*)—the foramen (*for*) marking the original line of separation between the two bones. In Dinosaurs and many other Reptiles the precoracoidal process has disappeared, and only the foramen remains; while in the Ichthyopterygia even this is wanting. A further reduction occurs in the higher Mammals, where the whole of the coracoid has disappeared as a distinct bone. The coracoid is subject to great variation in shape, and may either simply meet its fellow by an overlapping or sutural junction, or may articulate with the sternum.

A *clavicle*, mainly developed from membrane, may be connected with the preaxial borders of the scapula and coracoid; while a mesial T-shaped *interclavicle* (fig. 819), which is also developed from membrane, may receive the inner extremities of the two clavicles, and then usually overlies the upper part of the sternum. Finally, there may also be a single or double mesial *omosternum* developed on the ventral aspect from cartilage lying near the anterior extremity of the girdle. An illustration of the position of this bone is shown in the pectoral girdle of the Frog, represented in fig. 974.

In the pelvic girdle we have three separate ossifications arising in cartilage, of which all three usually unite to form an *acetabulum* (fig. 831,[2] *a*, *b*) for the reception of the head of the femur, or thigh-bone. The bone commonly known as the haunch-bone forms the dorsal element, and is technically termed the *ilium* (*ibid.*, *Il*); it corresponds to the scapula, and usually articulates with the sacrum by short ribs; while in the ventral half we have anteriorly the *pubis* (*ibid.*, *P*), representing the precoracoid; and posteriorly the *ischium* (*ibid.*, *Is*), which corresponds to the coracoid. The two latter bones

[1] This precoracoid appears to correspond with the bone termed *epicoracoid* by Professor Cope, and also the one so named in the Monotreme Mammals.

[2] Here the acetabulum is formed by only two bones, and it has been suggested that the bone lettered pubis may be really an epipubis.

very generally meet those of the opposite side in a ventral symphysis; and when, as is frequently the case, the three bones of either side are anchylosed together, an *innominate* bone results (fig. 1128 *bis*). The ischium and pubis of the same side may also unite inferiorly so as to enclose the *obturator notch*, *F*, which then forms the *obturator foramen* (fig. 1128 *bis*); while an *obturator process* of the ischium may form a smaller foramen below the acetabulum, as in the pelvis of *Camptosaurus*, figured in the sequel (fig. 1052). As a rule, there is no tendency to a reduction in the number of the pelvic bones in the higher forms. It may be mentioned, in conclusion, that a median ossification at the ventral symphysis of the pubis and ischium found in certain *Edentates* has been named the *pelvisternum*, and regarded as the abdominal representative of the sternum. This appears, however, to correspond with the median ossification found in the Ungulates (fig. 1128 *bis*), which is generally looked upon merely as an epiphysis. The pectoral and pelvic girdles of Fishes are noticed in the next chapter.

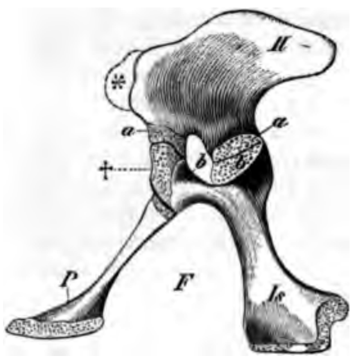


Fig. 831.—Lateral aspect of the left half of the pelvis of a young Crocodilian (*Alligator*). *Il*, Ilium; *P*, Pubis; *Is*, Ischium; *F*, Obturator notch; *a*, *b*, *b*, Acetabulum, with its vacuity; †, *, Cartilaginous extensions of ilium.

It may be well to observe here that genera being purely and simply artificial divisions formed for the convenience of classification, it is quite unnecessary that they should be of equivalent value in different groups of animals. As examples of vertebrate groups in which generic terms are used in a wide sense, we may cite the Reptilan order Sauropterygia and the Mammalian family *Rhinocerotidæ*; while as instances where a more restricted application is employed, we may mention the order Chelonia, and the family *Bovidæ*. The statement we not unfrequently hear that such-and-such a form *must* represent a distinct genus implies a total misconception of the import of generic terms.

CHAPTER XLVI.

CLASS PISCES.

General Structure.

The members of the class Pisces, commonly known as Fishes, form the first division of Professor Huxley's Ichthyopsida, and are generally characterised by living in water; breathing by branchiæ, or gills, throughout life; having the heart furnished with a single ventricle and auricle (atrium); having the limbs, when present, in the form of fins; being provided with unpaired median fins supported by fin-rays; and by the skin being either naked, or covered with dermal scales or bony scutes. There is no amnion or allantois developed in the embryo, and the reproduction is nearly always oviparous. Certain forms do not, however, exhibit all the above features, and the relation of the more generalised Fishes to the Amphibia is very intimate. The peculiar system of mucous canals and the lateral line are highly characteristic of Fishes, although they are not invariably present.

Before noticing such features as are of especial importance to the palæontologist, it will be convenient to mention that according to the arrangement adopted in this work the class is divided into the following six orders—viz., Cyclostomi, Elasmobranchei, Chimeroidei, Dipnoi, Ganoidei, and Teleostei, of which the salient features will be noticed in the succeeding chapter. Dr Günther has, indeed, proposed to bracket together the second, third, fourth, and fifth orders as a subclass under the name of Palæichthyes, ranking as equivalent to the Cyclostomi and Teleostei. Professor Huxley, Dr Traquair, and others have, however, shown that the Ganoidei are so intimately connected with the Teleostei, while the Elasmobranchei, Chimeroidei, and Dipnoi differ in so many respects among themselves and from the former, that such a grouping does not appear consonant with their true relationship.

Another scheme, proposed by Professor Cope and adopted by

Mr Smith-Woodward, is to brigade the Teleostei and Ganoidei together in a subclass under the name of Teleotomi, with ordinal divisions differing somewhat from the subordinal ones employed below, and to raise the Dipnoi, Chimeroidei, Elasmobranchei, and Cyclostomi to the rank of subclasses, with the concomitant elevation of their respective suborders to the rank of orders. It seems, however, scarcely to harmonise with the divisions adopted in the other classes of Vertebrates to regard a group like the Chimeroidei as a subclass, and accordingly the view of Professor Huxley is provisionally followed of regarding the Elasmobranchei and Chimeroidei as divisions of ordinal value.

Although the body in all Fishes must be adapted for progression through the water, yet there is an enormous range of variation in its contour among the different groups, as we may observe when we contrast a Lamprey, a Shark, a Flat-fish, a Ribbon-fish, and a Globe-fish. The dermal structures termed scales, which are so characteristic of Fishes, present many types of structure. In the Teleostei they usually form thin plates, frequently marked by concentric lines and not formed of true bone.

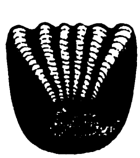


Fig. 832.—Cycloid scale, enlarged.

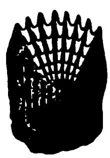


Fig. 833.—Ctenoid scale, enlarged.

When the posterior margin is simple (or entire) such a scale is termed *cycloid* (fig. 832), but when denticulated, *ctenoid* (fig. 833). Other examples of this type are shown in figs. 834, *a*, *b*. In many Ganoids and a few Teleosteans the scales are much thicker, and consist of a variety of true bone covered externally with an enamel-like substance termed *ganoine*. Such scales, of which specimens are shown in fig. 834, *e*, and fig. 835, are termed *ganoid;* they are arranged in oblique rows, and connected together by a peg-like projection, their shape being oblong. Scales of ganoid structure may, however, be much thinner, and resemble the cycloid type in their contour and their imbrication.

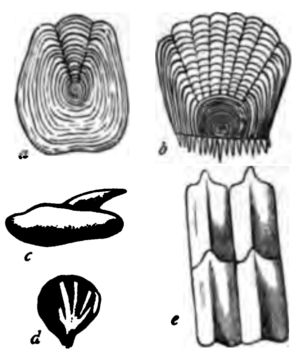


Fig. 834.—*a*, Cycloid scale of Pike (*Esox*); *b*, Ctenoid scale of Perch (*Perca*); *c*, Dermal plate of Thornback (*Raia*); *d*, Do. of Monkfish (*Squatina*); *e*, Ganoid scales of *Palæoniscus*. *a* and *b* enlarged.

Lastly, the bony dermal scutes or plates, frequently armed with a spine, which occur in the skin of the Sharks and Rays (fig. 834, *c*, *d*), are strictly comparable in structure to teeth, consisting of pectoral fins may be developed into huge dermal spines, which in some cases articulate by a complete shackle-joint with the basal bones. Similar spines are also developed in the Elasmobranchei

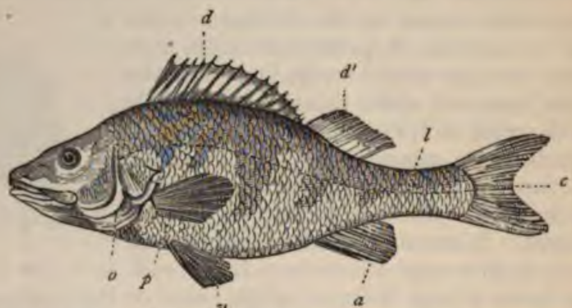


Fig. 837.—Left lateral view of the Perch (*Perca*). *o*, Gill-cover, with gill-slit behind it; *p*, Pectoral fin; *v*, Pelvic do.; *d*, First dorsal do.; *d'*, Second dorsal do.; *l*, Lateral line. Reduced.

(fig. 838); but here they are simply inserted into the flesh, or are attached only by cartilage, so that their basal end is rounded off. Similar spines (fig. 838, 1) may also occur behind the head. Such

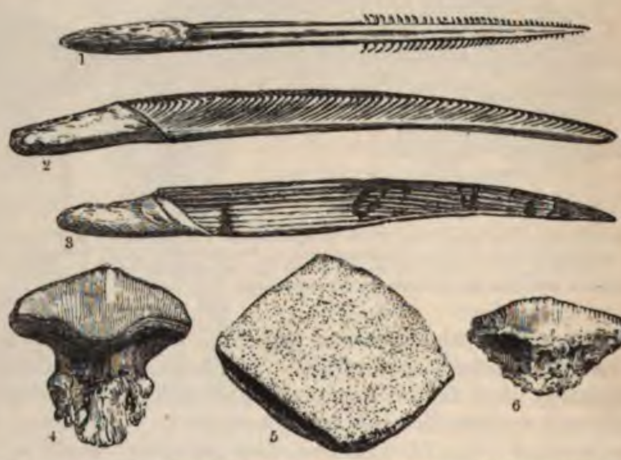


Fig. 838.—Spikes and teeth of Elasmobranchei. 1, Nuchal spine of *Pleuracanthus*; 2, Fin-spine of *Gyracanthus*; 3, Do. of *Ctenacanthus*; 4, Tooth of *Petalodus*; 5, Do. of *Psammodus*; 6, Do. of *Ctenoptychius*. Carboniferous. 1–3 are reduced.

spines when found fossil are frequently known as *ichthyodorulites*, and form important objects to the palæontologist. Their structure is identical with that of the so-called placoid scales and of teeth, there being a central pulp-cavity, surrounded by a layer of dentine or vasodentine, which is covered with enamel.

The teeth of Fishes present a greater amount of variation than is found in any other class. They may be entirely absent, or may be present on all the bones of the mouth, and also on the hyoids and branchial arches, while they may be attached merely to the membrane of the mouth-cavity. Very frequently they are attached by anchylosis to the underlying bone or cartilage (fig. 838), but they may be implanted in distinct sockets or alveoli. The dentine is usually distinguished from that of the teeth of higher Vertebrates by its greater vascularity. The coating of enamel is generally very thin; but it is more developed in the cutting-teeth of *Sargus*. Occasionally (*Dendrodus*) radiating prolongations of the pulp-cavity may penetrate the dentine from the centre to the periphery, thus producing a structure like that of the teeth of the Labyrinthodont Amphibians. There is generally a constant renewal of the teeth of Fishes during the whole of life; but occasionally one set persists.

Fig. 839.—Anterior aspect of a caudal vertebra of a Teleostean Fish *ns*, Neural spine; *na*, Neural arch; *z*, Articular processes; *ha*, Hæmal arch; *hs*, Hæmal spine. (After Günther.)

Turning to the endoskeleton, and commencing with the vertebral column, we find that the vertebræ can only be divided into a trunk and a caudal series, and that there is a gradual progression in respect of ossification from the lowest to the highest forms. Thus, in the Cyclostomi, the notochord persists throughout life, and is generally unsegmented, although rudimental neural arches and spines are developed in *Petromyzon*. The vertebral column of the Cartilaginous Ganoids is very similar to that of the latter; but in Bony Ganoids, Elasmobranchei, and Teleostei paired cartilages, arising both above and below the notochord, gradually surround it, and thus form strongly amphicœlous vertebral centra. In the Sharks these centra exist without arches, but in the other orders there are well-developed neural arches; and in the trunk region there are also lateral *basal processes*, which in the tail unite inferiorly to form a hæmal arch for the caudal artery, and develop a hæmal spine (fig. 839). There is a great tendency for the neural arches to remain open superiorly; and the only Fish in which the vertebræ are not amphicœlous is the Ganoid *Lepidosteus*, in which they are opisthocœlous. Only in the Chimeroidei and certain Elasmobranchei are there definite articulations between the vertebral column and the cranium; the posterior aspect of the basioccipital in other groups forming a cup like that of a vertebral centrum. The mode in which the vertebral column terminates posteriorly is of considerable importance in classification. The most primitive

Fig. 840.—A, *Polypterus*, and B, *Osteolepis* (Ganoids), to show diphycercal caudal fin. *a*, Pectoral; *b*, Ventral; *c*, anal; *d*, Dorsal fin. Reduced.

type occurs in the Cyclostomi, Dipnoi, and many Ganoids, where the notochord continues to the extremity of the body, and is symmetrically surrounded by the caudal fin, as in fig. 840; this type is known as *diphycercal*. In the other, or *heterocercal* type, the notochord

Fig. 841.—A, Sword-fish; B, Sturgeon, to show masked (homocercal) and typical heterocercal tail.

is bent upwards, owing to the greater development of the lower as compared to the upper half of the tail. This feature may be observable externally, as in the Sturgeons (fig. 841, B) and Sharks; or may be masked, as in the majority of Teleostean Fishes (fig. 841, A), by the symmetrical arrangement of the fin-rays. The skeleton (fig.

842) shows, however, the upward bend of the notochord, although this is very much less marked in the adult than in the young. This masked heterocercal type is sometimes described as *homocercal.* The coalesced hæmal spines found in this type of tail are known as *hypural* bones (fig. 842, *h*), while the ossified extremity of the notochord is termed the *urostyle*.

Fig. 842.—Tail of Flounder. (After Agassiz.) *v*, Vertebral column; *n*, Turned-up end of the notochord; *h*, Hypural bones.

The skulls of Fishes present variations in regard to their degree of ossification, analogous to those obtaining in the vertebral column. The general structure of the primitive cartilaginous skull has been already indicated in Chapter xlv. (fig. 822), but we must here glance briefly at certain bones developed in the more specialised forms which are peculiar to the class. Thus, taking as an example the skull of a Teleostean Fish (fig. 843), where the primitive cranium is concealed by the development of investing bones, we find two peculiar ossifications in the auditory region known as the pterotic (*ibid.*, *Pte*), which is considered to represent the squamosal and opisthotic of higher Vertebrates, and the sphenotic (*ibid.*, *Sph*). A large parasphenoid is always present inferiorly (fig. 844). The intervention of the hyomandibular and symplectic (figs. 823 and 843) between the quadrate and the squamosal region has been already mentioned in Chapter xlv. as peculiar to Fishes (although it is by no means universal in the class); and we must also mention that, in addition to the normal palatine and pterygoid bones developed

Fig. 843.—Left lateral view of the skull of a Trout (*Salmo*). *Ep*, Epiotic; *Pte*, Pterotic; *Sph*, Sphenotic; *Os*, Supra-occipital; *P*, Parietal; *F*, Frontal; *Sp.eth*, Ethmoid; *Can*, Aperture of olfactory nerve; *Nl*, Nasal; *Pmx*, Premaxilla; *M*, *M*[1], Maxilla; *Ig*, Jugal; *Ms*, Mesopterygoid; *Mtp*, Metapterygoid; *o*, *o*, Suborbitals; *Hm*, Hyomandibular; *s*, Symplectic; *Qu*, Quadrate; *Pr*, *Iop*, *Sop*, Pre-, inter-, and suboperculum; *Op*, Operculum; *BsS*, Branchiostegal rays; *Ar*, Articular; *De*, Dentary; *A*, eye. (After Wiedersheim.)

round the cartilaginous palatopterygoid bar, there occur in Teleostei the *meso-* and *metapterygoid* (fig. 843, *Ms*, *Mtp*). In the same class the orbital region likewise develops a series of membrane-bones round the eye, forming the *suborbitals* or *orbital ring* (*ibid.*, *o*, *o*), while the *gill-cover* or *operculum* (of which the first trace is found in the Chimæroids in a fold from the hyomandibular overlapping the first gill-slit) is formed by the *preopercular*, *opercular*, *subopercular*, and *infraopercular* (*ibid.*, *Pr*, *Op*, *Sop*, *Iop*), which are broad, scale-like membrane bones. In the *branchiostegal membrane*, which unites with the gill-cover in closing the branchial chamber, there is developed a number of *branchiostegal rays* (fig. 843, *BsS*, and fig. 844, *bo*); but these may be partly or entirely replaced by

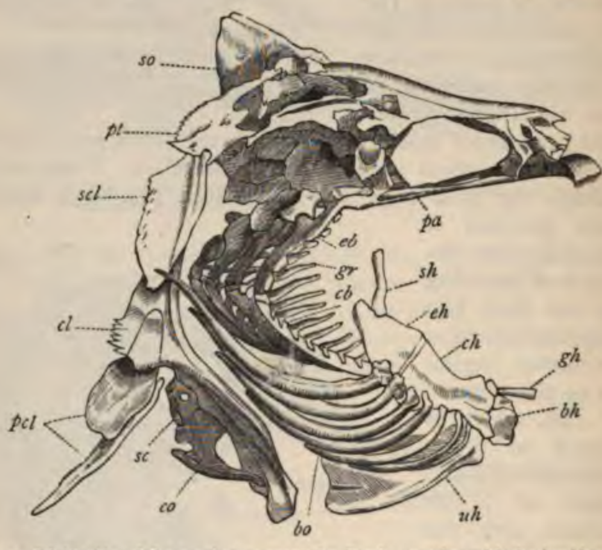


Fig. 844.—Right side of the cranium proper of a Perch, together with the hyoid and branchial arches, and the pelvic girdle. *sh*, Stylohyal; *eh*, Epihyal; *ch*, Ceratohyal; *bh*, Basihyal; *gh*, Glossohyal; *uh*, Urohyal; *bo*, Branchiostegal rays; *cb*, Ceratobranchial; *eb*, Epibranchial; *gr*, One of the "gill-rakers" of the first branchial arch; *pa*, Parasphenoid; *so*, Supraoccipital; *pt*, Posttemporal; *scl*, Supraclavicular; *cl*, Clavicular; *pcl*, The two pieces of the postclavicular; *sc*, Scapula; *co*, Coracoid.

jugular plates, occupying the space between the rami of the mandible. The hyoid arch (fig. 844) is attached to the inner side of the hyomandibular by a *stylohyal* (*ibid.*, *sh*), articulating inferiorly with the *epihyal* (*eh*), and the latter with the large *ceratohyal* (*ch*); the two latter carrying the branchiostegals. The inferior part of this arch is formed by the *basihyal* (*bh*), from which the *glossohyal* (*gh*) extends forwards into the tongue, and posteriorly articulates with the first of the *basibranchials*, mentioned below. The *urohyal* (*uh*) is a vertically-compressed median bone, extending backwards from the basihyals. Behind the hyoid arch occur the *branchial arches*, the first of which consists of a median *basibranchial*, and laterally from below upwards of a *hypobranchial*, *ceratobranchial* (fig. 844, *cb*), *epibranchial* (*eb*), and *pharyngobranchial*. The latter bones in the second and third arches are called *superior pharyngeals*, and generally carry teeth. Finally, the *gill-rakers* (fig. 844, *gr*) are spine-like bones attached to the inner margins of the branchial arches.

In the mandible there is usually (fig. 843) a dentary and articular piece; but an angular, and more rarely a splenial or coronoid, may also be present.

In the appendicular skeleton, we find the pectoral girdle of Ganoids and Teleosteans consisting inferiorly of the primary cartilaginous elements corresponding to the scapula and coracoid (fig. 844, *sc*, *co*), and superiorly and laterally of a secondary chain of bones developed from membrane, and articulating superiorly with the pterotic region of the skull. The bones of this secondary chain are named from above downwards *posttemporal* (fig. 844, *pt*), *supraclavicular* (*scl*), *clavicular* (*cl*), and a *postclavicular* of two pieces (*pcl*); while there may be also an *infraclavicular* below the clavicular. In Elasmobranchei only the cartilaginous primitive girdle is developed; while in Dipnoi the girdle is of very peculiar structure, and somewhat intermediate between that of Elasmobranchei and Teleostei. The pelvic girdle is generally wanting; but in the Dipnoi there is a median cartilaginous plate, with anterior and posterior paired processes, of which the former are iliac, and the latter give attachment to the hind limbs. Elasmobranchs generally show a degenerate pelvis of this type.

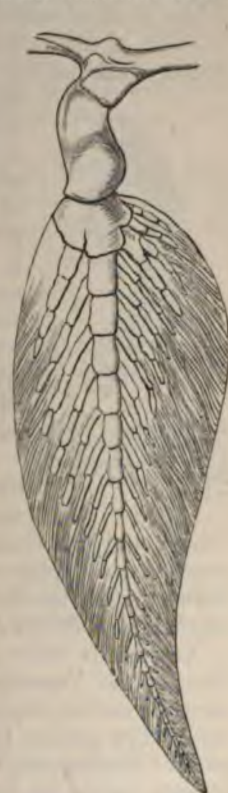


Fig. 845.—Skeleton of the left pectoral limb of *Ceratodus*. Reduced. (After Günther.)

The pectoral and pelvic limbs, or fins, are so similar in structure that they may be considered together, although the development of the latter is less specialised than that of the former. No representatives of the arm and fore-arm of the higher Vertebrates can be detected in Fishes, the basal and radial bones or cartilages articulating directly with the pectoral girdle. In the Dipnoi, and especially in *Ceratodus*, the pectoral (fig. 845) and pelvic fins are supported by a cartilaginous, median, segmented axis, bearing jointed radii on the dorsal and ventral borders—these radial cartilages being terminated by horny dermal fin-rays; and the dorsal radii (left side of figure) being more numerous than the ventral. This type of fin, which also occurs in the Ichthyotomous Elasmobranchei, is known as the *archipterygium*. From this slightly unsymmetrical type of fin that of existing Selachian Elasmobranchs (fig. 846) may be derived by the gradual suppression of the ventral series of rays, and the development of the dorsal, which has now become lateral. Basally the jointed radial cartilages articulate proximally with the *pro-*, *meso-*, and *metapterygium*, which in their turn are attached to the pectoral arch, and the latter of which corresponds to the basal axial cartilage of the fin of *Ceratodus* (fig. 845). In the pelvic fin of the Selachians the mesopterygium is absent, and the propterygium more or less rudimentary. This type of fin is known as the *ichthyopterygium*. The fins of Ganoids and Teleosteans may be derived from the Selachian type; but the primary cartilaginous skeleton is reduced, and a secondary one developed by the introduction of membrane bones.

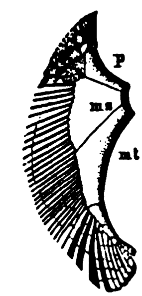


Fig. 846.—Skeleton of the left pectoral limb of the Monkfish (*Squatina*). *p*, Pro-; *ms*, Meso-; *mt*, Metapterygium. Much reduced.

Before leaving the structure of Fishes, mention must be made of the *otoliths*, which are small, rounded, elliptical bodies, usually with one convex and one concave side, lying in the tympanic sac, and composed of both calcic carbonate and phosphate. These bodies have been carefully studied by Dr Koken, and several genera identified by their evidence in a fossil state.

As regards their distribution in time, Fishes being the lowest class of the Vertebrata, it would naturally be supposed that they were the earliest representatives; and this appears to have been the case. The earliest known fishes in Britain belong to the Ganoid group *Placodermata*, and occur in the Lower Ludlow group of the Silurian; while the Elasmobranchei were represented in the topmost group of the same series. In the Devonian and Carboniferous periods Fishes become abundant; but all the forms from these horizons, and up to the Cretaceous, belong to the Elasmobranchei, Chimæroidei, Dipnoi, and Ganoidei—the specialised Teleostei not making their appearance, so far as we know with certainty at present, till the Cretaceous. The Ganoids of the suborder Amioidea approximate, however, so closely to the Teleostei, that it has been a question whether some of the members of the Jurassic family *Lepto-*

lepidida, which are usually placed in the former, should not be transferred to the latter group; and we may thus confidently expect to find a complete transition between the two. Although many of the Cretaceous Teleostei are more or less closely allied to existing types, it is not until the Eocene that we find a fish-fauna comparable to that of the present day; and we may note that the resemblance of the fishes of the Eocene to those now living is in marked contrast to what obtains in Mammals, where the majority of Eocene genera are extinct. The persistence of some genera of Fishes throughout long geological epochs is indeed a noteworthy circumstance, and is nowhere more marked than in the case of *Ceratodus*, which has lived on continuously from the Triassic period of Europe, and also from that of certain North American beds, which are usually referred to the Permian.

In regard to the origin of the various orders of Fishes, it is pretty evident that the Teleostei were derived from the Ganoidei, and that the Dipnoi were closely related to one branch of the latter. The

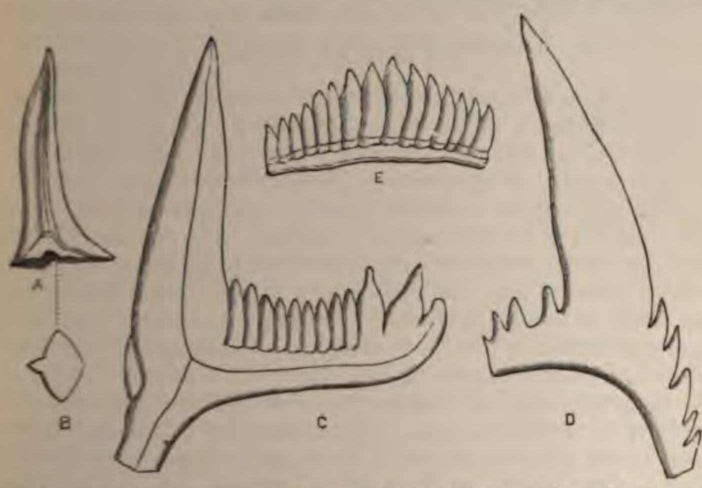


Fig. 847.—Conodonts, greatly enlarged. A, B, *Acodus acutus*; C, D, *Prionodus elegans*; E, An unnamed form; A–D, From the Silurian of Russia; E, From the Carboniferous of North America. (After Pander and Newberry.)

phylogenetic relationship of the Ganoids to the Elasmobrancheans is, however, still unsettled, although recent researches tend to show a close connection between the more primitive and least specialised groups of the two orders. Palæontology has not, indeed, yet taught us from what group of animals these primitive Ganoids and Elasmobranchs were themselves derived. It has, however, been suggested by Professor Cope that the Placodermoid Ganoids were closely related to the Ascidian Invertebrates; and if this suggestion prove well founded, it would seem to indicate that the grou tioned is closely allied to the real ancestors of the class. P however, these ancestors are to be sought in another directio it has been thought that minute tooth-like bodies found i ranging from the Upper Cambrian to the Carboniferous, and as *Conodonts* (fig. 847), are really the teeth of Fishes. It w sidered probable at one time that these curious fossils, whicl exceed two millimetres in length, might be teeth of extinct m of the Cyclostomi; but their internal structure is so differe the teeth of the existing forms of that order, that if they be Fishes at all, they must apparently indicate an extinct divisi great variety of forms of these Conodonts have been describ have received distinct generic and specific names. It is the of some authorities whose judgment is entitled to great co tion that these fossils should be regarded as the jaws of An or Trilobites; but the question as to their real nature n regarded as still undecided.

[1] *Vide supra*, vol. i. p. 480.

CHAPTER XLVII.

CLASS PISCES—continued.

Orders Cyclostomi and Elasmobranchei.

Order I. Cyclostomi. — The Cyclostomi, which include the Hag-fishes (*Myxine* and *Bdellostoma*) and Lampreys (*Petromyzon*) being at present unknown in a fossil state, require no further notice in the present work.

Order II. Elasmobranchei.—This order, which is also known under the name of Chondropterygii, includes a peculiar extinct group termed the Ichthyotomi, together with the modern Sharks, Dog-fishes, Saw-fishes, and Rays, collectively constituting the Selachii, and all of which are typically of marine habits. For palæontological purposes this order may be characterised as follows: The skeleton is invariably cartilaginous, and membrane bones are, with some possible exceptions, absent in the skull; the vertebral column is, however, generally divided into distinct segments, of which the centra may be marked by a calcification differing in structure from true bone. In the skull, which may be either movably or immovably connected with the vertebral column, the palatopterygoid bar and hyomandibular suspensorium are never fused with the cranium. When an exoskeleton is developed, it consists of small dermal granules, of which the structure is the same as that of teeth. In all existing forms the optic nerves simply cross one another, without any interlacing of their component fibres; the bulbus arteriosus of the heart has three series of valves; the intestine is furnished with a spiral valve; and the ova are of large size and few in number.

A few words may be said explanatory of some of the above-mentioned and other features in existing forms before proceeding to the systematic part. In all forms, as already mentioned, there is a separate suspensorial arrangement articulating with the cranium, to which the mandible is attached; this structure being termed *hyostylic*. Usually there is a hyomandibular suspensorium intervening between the cranium and the palatopterygoid bar; but in *Notidanus* (fig. 861) the hyomandibular element takes no share in the support of the mandible, and the palatopterygoid articulates directly with the cranium; this probably being the primitive type. The gills (fig. 848) are attached to the skin by their margins; while they usually communicate with the exterior by five apertures, or clefts, which may be very rarely increased to six or seven. The mouth is very generally situated on the inferior aspect of the body (fig. 849), and is furnished with numerous teeth carried on the palatopterygoid bar and Meckel's cartilage (fig. 861). These teeth may be either sharp and separate, or articulated together so as to form a more or less pavement-like structure; and in the former case there is a continuous succession of new teeth developed from behind as the old ones are worn out. Both median and paired fins are present; the position of the pelvic pair being always abdominal. In all existing forms the skeleton of the limbs forms an *ichthyopterygium* (fig. 846); but in the Carboniferous and Permian Ichthyotomi there is either a uniserial or biserial *archipterygium*, like that of the Dipnoi. The posterior termination of the vertebral column is generally heterocercal, with the upper lobe of the caudal fin greatly elon-

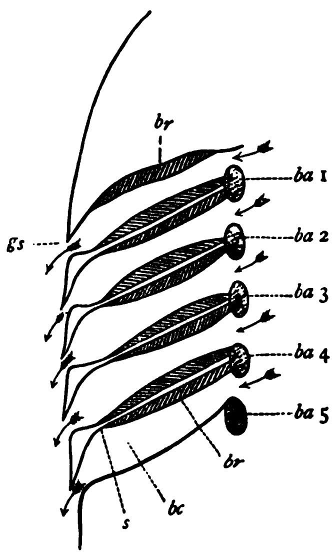


Fig. 848.—Diagram of one side of the gills and gill-pouches in a Selachian; the arrows indicating the direction of the currents. *ba* 1–5, Branchial arches transversely divided; *bc*, Branchial pouches; *gs*, External gill-slits; *s*, Septa between pouches; *br*, Branchiæ.

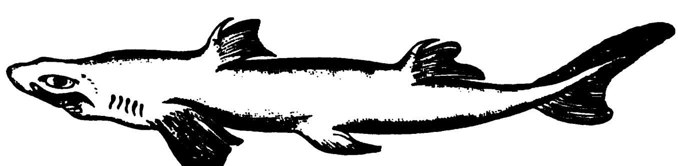


Fig. 849.—Spiny Dog-fish (*Acanthias*). Reduced.

gated (fig. 849). The spines frequently borne by the dorsal fins and in the nuchal region, constituting the so-called ichthyodorulites, have their bases simply embedded in the flesh, and are consequently immovable. There is no swim-bladder. The term *spiracles* is ap-d to apertures connected with respiration found on the upper ct of the head; while the *intercalary cartilages* are ovoid or iond-shaped structures occurring between the neural arches of ertebræ.

r Smith-Woodward observes that a gradual advance in the de- of calcification of the axial skeleton may be observed as we trace nembers of the order from the Palæozoic upwards, the oldest not having the notochord differentiated into distinct vertebral , of which we find the first complete types in the Lower Liassic *spinax*. Here, however, the centra merely assume the form uble cones, only very slight traces of the peripheral calcifica- necessary to form the biconcave centra of the later types being . In the Lower Kimeridgian lithographic stone of the Con- , centra of the complete *asterospondylic* type are first met with. e same authority mentions that the Palæozic types are, as a characterised by the great development of the exoskeleton, gh a few forms like *Pleuracanthus* appear to have had naked . These early dermal structures are also noticeable for their ate sculpture, this being equally developed on the dermal es (shagreen), and on the fin and cephalic spines. Smooth nes appear to be very rare in the Palæozoic, and it is not till ch the Upper Trias and Lias that spines completely covered mooth ganoine are met with.

regard to the teeth, Mr Woodward observes that "pointed and obtuse teeth occur among the earliest Elasmobranchs; e former as well as the latter are firmly articulated together, ust always have formed part of a dentition in which several were functional. Though the teeth of *Cladodus* and *Diplo-* *leuracanthus*] are as sharply pointed as those of most recent , the piercing crown is placed upon a broad horizontally- led base, permitting of a considerable amount of interlock- tween one tooth and another—an arrangement most nearly led in the surviving *Chlamydoselache*. It is evident, indeed, l the modern types of dentition, in which not more than one series of teeth are simultaneously functional, are highly speci- modifications of this primitive arrangement; and the change from the deepening and lateral compression of the root of ooth, rendering its base of support less fixed, and often not ting its coming into use until after attaining the summit or g the outer side of the jaw-cartilage.

ith regard to the disposition of the teeth in the mouth as a , the modern Rays—most *Scylliidæ* and *Chlamydoselache*—may ked upon as retaining the most primitive arrangement. In edaceous Sharks there has been a tendency towards the rela- nlargement of the prehensile teeth upon the symphysis; while in the Cestraciont Sharks the symphysial teeth have become smal[ler], though prehensile, and the lateral teeth well adapted for trituration. The former arrangement is particularly characteristic of modern times; the latter, it is interesting to note, attained its maximum of specialisation so long ago as the Carboniferous period. In many early Carboniferous genera the series of lateral crushing-teeth began in part to fuse into continuous plates (*Pleuroplax*); two of these plates often amalgamated (*Pœcilodus*); and in the most specialised of these Cochliodonts (*e.g.*, *Deltoptychius*), all traces of the boundaries of the original components of the dental plates became obliterated."

SUBORDER 1. ICHTHYOTOMI.—This name was proposed by Professor Cope for a group of primitive Elasmobranchs, ranging from the Devonian to the Permian, but perhaps also surviving to the Trias, and showing the following characteristic features. The endoskeleton has granular calcifications extending equally throughout the cartilage; the notochord in most, or all, cases is not constricted to form distinct vertebræ; and the calcification of its sheath in the precaudal region does not extend beyond that very incomplete stage to which the term *rhachitomous* has been applied—the explanation of which is given below under the head of the Labyrinthodont Amphibians. The neural and hæmal spines of the vertebræ are long and slender, and no intercalary cartilages are developed. Finally, the pectoral fins have a long segmented axis of the archipterygial type (fig. 850).

It may be mentioned here that Dr Koken is indisposed to admit the right of the Ichthyotomi to form a group of equal rank, with that embracing all other Elasmobranchs; since he regards the primitive features exhibited by the vertebral column, and the nature of the caudal fin, as only one degree removed from those found in certain Selachii. This writer, indeed, regards the *Pleuracanthidæ* and *Cladodontidæ* as so closely allied to the *Notidanidæ* and *Cestraciontidæ* (*Hybodontidæ*) that he would class the whole of these families in a single group, for which he proposes the name *Proselachii*, and in which the *Cochliodontidæ* should perhaps also be included. So far as regards the slight importance from a classificatory point of view of the imperfect calcification of the vertebral column, Dr Koken's views are in harmony with those adopted below in the classification of the Labyrinthodont Amphibia.

FAMILY PLEURACANTHIDÆ.—In this family the body is slender and somewhat depressed; the mouth differs from that of all the Selachii in being terminal; while the caudal fin is diphycercal. There is a long and low continuous dorsal fin; while the pectoral fin has a biserial arrangement of rays somewhat after the fashion of *Ceratodus*. The type genus *Pleuracanthus* has received an almost bewildering number of names, of which it will suffice to mention *Diplodus*, *Orthacanthus*, *Xenacanthus*, and *Didymodus*; some of these, as their terminations indicate, having been applied to spines, and others to teeth.

Recent discoveries have enabled us to attain to a nearly complete knowledge of the anatomy of this remarkable genus, and a restoration by M. Brongniart of one of the species is shown in the accompanying woodcut. The skin was quite naked; the body elongate, and the snout obtuse. The teeth have a thick and depressed root, with a crown formed by two unequal corners diverging like a V, with a small denticle at the base of the two, and not unfrequently a minute flattened mammilla posteriorly. In the male the pelvic fins carry a robust "clasper." At the top of the head there was a large barbed spine (fig. 852, 1), with a double row of serrations, and, according to the restoration (fig. 850), supporting a

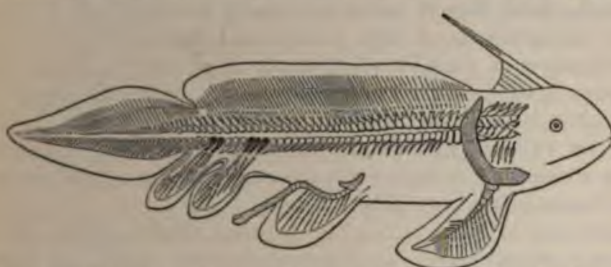


Fig. 850.—Restoration of the skeleton of *Pleuracanthus Gaudryi*; from the Carboniferous of France, reduced. (After Brongniart.)

cephalic fin. In the skull, according to Dr Koken, there was a distinct hyomandibular, but the palatopterygoid bar had a direct connection with the postorbital process of the cranium, as in *Notidanus*. Dr Koken would slightly modify the structure of the pectoral fin from that given in fig. 850. The dorsal fin is of great length, extending backwards as far as the diphycercal caudal, from which it is separated by a deep notch. According to M. Brongniart's restoration the anal fin was double, and its two divisions had a structure curiously like that of limbs; Dr Koken considers, however, that the restoration is incorrect in this particular. Specimens of the figured species attain a length of more than a yard.

In time this genus extends from the Carboniferous to the Lower Permian; while in space its range embraces both Europe and North America. *Chondrenchelys*, from the Lower Carboniferous of Dumfriesshire, which is provisionally referred to the same family, has no cephalic spine. Detached teeth from the Keuper of Somerset, described under the name of *Diplodus*, apparently indicate the survival of a form allied to *Pleuracanthus* in the Triassic period.

FAMILY CLADODONTIDÆ.—The second family of this suborder is too imperfectly known to admit of definition; but it appears that in the type genus the pectoral fin had only one series of rays, and was thus intermediate between that of *Pleuracanthus* and the fins of the Selachii. The type genus *Cladodus* had a broad and depressed head, with the teeth arranged in numerous rows. The crowns of these teeth present some resemblance to those of the Selachian *Hybodus* (fig. 865); consisting of one large cone, flanked on either side by one or more smaller cones, of which the outermost is generally the largest. This genus is exclusively Carboniferous, and occurs both in Europe and North America; a large number of species being known. *Dicentrodus*, of the Scottish Carboniferous, is distinguished by the teeth having only a single lateral cone developed on one side. *Phœbodus*, of the Devonian of Iowa, is an allied genus, with the lateral cones of the teeth at least as large as the middle cone; while in *Lambdodus*, of the North American Palæozoic, these lateral cones are totally wanting. In *Dicrenodus*, of the Carboniferous of both Europe and North America, we have a modification of the Cladodont tooth, in which the central cone is compressed, with the cutting-edges serrated; while the lateral cones may either be two in number, or absent. Finally, the North American Palæozoic genus *Hypocladodus* differs from the preceding by the absence of serrations on the edges of the central cone; the lateral cones being invariably absent.

SUBORDER 2. SELACHII.—The existing Sharks, Rays, and their allies are characterised by the endoskeleton being, as a general rule, only superficially calcified; while, except in some of the earlier forms, the notochord is constricted at the centre of each vertebra. The neural and hæmal arches of the vertebræ are short and stout; and intercalary cartilages are nearly always developed. The pectoral fin (fig. 846) has not a segmented axis, being of the ichthyopterygial type; and the axis of the pelvic fin of the male is produced into the so-called "clasper," which is connected with reproduction. Some of the other features of this suborder have been already mentioned at the commencement of this chapter. The Selachians may be divided into two sections, according to the structure of the vertebral centra. In the one the anal fin disappears, and there is a tendency to the depression of the body and the enlargement of the pectoral fins, but there is no diminution in the size of the spiracle, and the vertebræ, when fully developed, are of the type known as *tectospondylic*. In the other section the anal fin persists; the shape of the body is always rounded—not even excessively flattened in the *Scilliidæ;* the spiracle tends to abort, and may be almost or totally absent in the most specialised forms; while the fully developed vertebræ are of the type known as *asterospondylic*. The type of vertebral centra known as *cyclospondylic* occurs in the immature condition of both sections.

SECTION A. TECTOSPONDYLI.—In this section the vertebral centra, when fully calcified, have the concentric laminæ predominating over those that radiate from the centre. The anal fin is invariably want-hile specialisation shows itself in the depression of the body : enlargement of the pectoral fins—the spiracles being always l. This section includes the Spiny Dog-fishes, Saw-fishes, ıys, and Rays.

LY SPINACIDÆ.—In this family, which includes the exist- ly Dog-fishes (fig. 849), we have generalised forms, with the ore or less rounded, and but slightly depressed. The teeth ted; the pectoral fins are devoid of a notch at their root, not expanded anteriorly; while the gills are small and nd the spiracles large. One fossil species referred to the Mediterranean genus *Centrina* has been recorded from the of Italy; but this determination is not absolutely certain. *s* (fig. 849), of which two species are found at the present ie temperate seas of both hemispheres, occurs in the Chalk ebanon, and also in the Miocene of Würtemberg. Another m from the Lebanon has been referred to the existing genus *orus*, but it may perhaps belong to *Acanthias*. The exist- is *Spinax* has been recorded from the Italian Pliocene. *mnus* we come to another existing genus, differing from all it precede by the absence of fin-spines. It occurs fossil in ene of Italy, which has also yielded remains referred to the *hinorhinus*.

Y PETALODONTIDÆ.—The Petalodonts form a family ex- Carboniferous, presenting the following characters. The s somewhat depressed, while the pectoral fins were large, luced forwards in the direction of the head after the manner Rays. The teeth (figs. 2) formed a close pave- the mouth, and are com- from before backwards, crown more or less bent ls, and either blunt and r with a cutting-edge, the ng often large. In the *anassa* (*Climaxodus* or *a*), which is common to and North America, the . 851) are so thickened ected, that the complete rms an almost entirely triturating surface. These teeth are in three chief rows, as in the figure, which gradually in size anteriorly, and are flanked by one or more smaller less thickened teeth. The body is covered with fine sha- The North American *Fissodus* has the margin of the crowns eth cleft into two or three points; while in *Petalorhynchus*,

Fig. 851.—Posterior aspect of some of the central teeth of *Janassa linguæformis*; from the English Carboniferous.

which is found both in Europe and North America, the teeth are of the same general type, but have more compressed crowns, with long undivided roots. Again, in *Petalodus*, which has the same distribution as the preceding, the teeth (fig. 852, 4) are much elongated transversely, and compressed from before backwards—the crown being petal-shaped, with a smooth or slightly crenulated cutting-edge. The nature of the arrangement of the entire series is, however, unknown. The teeth of *Ctenoptychius* (fig. 852, 6) are distinguished by the coarser denticulation of their cutting-edge—those of *Callopristodus*

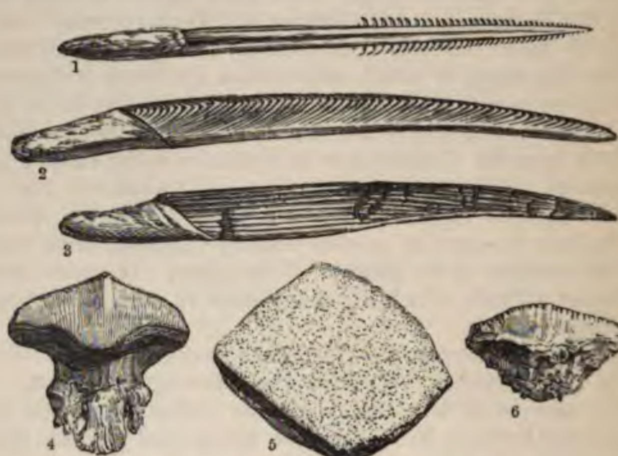


Fig. 852.—Spines and teeth of Carboniferous Elasmobranchei. 1, Nuchal spine of *Pleuracanthus lævissimus*; 2, Fin-spine of *Gyracanthus*; 3, Do. of *Sphenacanthus*; 4, Tooth of *Petalodus acuminatus*, seen from the side; 5, Do. of *Psammodus*, seen from above; 6, Do. of *Ctenoptychius*. 1–3 are reduced.

differing from the latter by the absence of enamel-folds at the base of the crown, and also by the nature of the root. It is probable that both these genera occur in North America as well as in Europe. In *Polyrhizodus* (*Dactylodus*), of both Europe and North America, the teeth are extremely stout, with low crowns, usually having a sharp cutting-edge devoid of crenulations, and a large root divided into a number of rootlets. Other allied genera from Europe are known as *Glossodus* and *Mesolophodus*.

Family Pristodontidæ.—This family is only known by the genus *Pristodus*, of the European Carboniferous, in which the crown of each tooth is thin, plate-like, and symmetrical, with hollows corresponding to elevations in the opposing tooth of the opposite jaw. It has been suggested that each jaw carried only a single tooth.

Family Squatinidæ.—With this family we come to a group represented at the present day by the Monkfish, of which the skele-of the pectoral fin is shown in fig. 846 (p. 920). The body is ssed, with the mouth placed anteriorly; while the pectoral re much produced anteriorly, although unconnected with ead. The teeth are conical inted; and the dorsal fins are t spine, and placed on the tail. ly known genus is *Squatina*), which ranges from the lgian upwards to the present lthough some of the fossil have been described under ames, such as *Thaumas.* lly preserved skeletons occur Lower Kimeridgian litho- limestones of Bavaria, one is shown in the accompany- dcut. Other species have med from the Chalk of the and of England, and also e Miocene and Pliocene of tinent; while detached teeth d in the English Gault, the Clay, and the Red Crag.

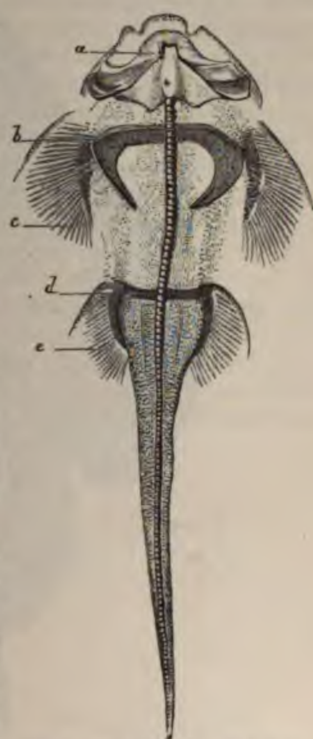


Fig. 853.—Ventral aspect of the skeleton of *Squatina speciosa*; from the Kimeridgian of Bavaria, two-thirds natural size. *a*, Mandible; *b*, Pectoral girdle; *c*, Pectoral fin; *d*, Pelvis; *e*, Pelvic fin.

LY PRISTIDÆ.—In the true es the body is scarcely de- the pectoral fins are not panded, and the gill-slits are nferiorly. The most charac- feature is, however, the so- "saw," which is a long and cified prolongation of the rmed with a series of large teeth on either border. Re- f the single existing genus ccur in the Middle Eocene n and Bracklesham; in the Middle and Lower Eocene and e of the Continent; and the Eocene and Upper Cretaceous h America. *Propristis*, from the Eocene of Egypt, is said by the absence of calcification in that part of the "saw" upports the teeth; *Amblypristis*, of the same beds, has and broader teeth than *Pristis*; while *Sclerorhynchus*, which long to the *Pristiophoridæ*, differs in the structure of the and the small size of the rostral teeth. The latter family, as lateral gill-slits, may be represented in the Miocene of berg by a species of the existing *Pristiophorus*.

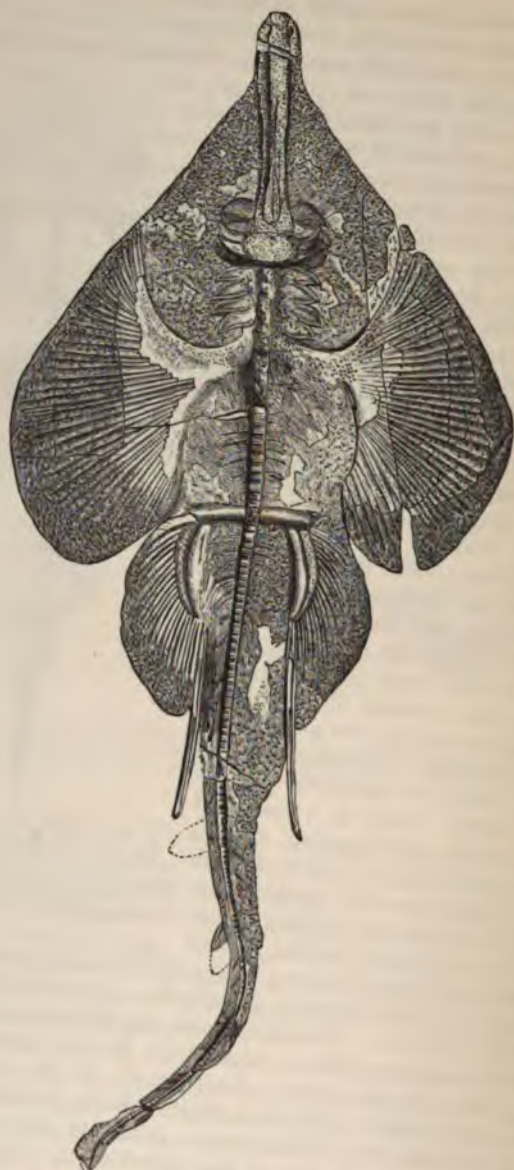


Fig. 854.—Skeleton of *Rhinobatis bugesiaca*; from the Kimeridgian of Bavaria, one-twelfth natural size. (After Zittel.)

ILY RHINOBATIDÆ.—With this family we come to Fishes to the general term Rays may be applied; all of them are terised by their extremely depressed bodies and the great de- ent of the pectoral fins, so that the body proper with its fins ed the "disk." The teeth always form a kind of pavement 56, 857). In the present family the tail is long and stout, o well-developed dorsal fins; while there is also a caudal fin, longitudinal fold on either side. The disk is not excessively ed; the rayed portion of the pectoral fins not extending to ut. The type-genus *Rhinobatis* (*Spathobatis*) is represented present day by about a dozen species, which inhabit the seas, and attain huge dimensions. The snout is produced ong rostrum, which is connected with the pectoral fin by a nous expansion (fig. 854). The teeth are obtuse; and the fins are devoid of spines. In time this genus ranges from neridgian to the present day; species being recorded from ographic limestones of Bavaria (fig. 854) and France; from tlandian of France; the Chalk of the Lebanon and Italy; ldle Eocene of Monte Bolca; the Miocene of Würtemberg; er localities. The Austral- *gonorhina*, which differs in icture of the nasal valves, to occur in the Middle of Italy. Finally, the gen- *mnobatis* and *Asterodermus*, vely from the Kimeridgian ice and Bavaria, appear to the present with the fol- family.

Fig. 855.—The Burton Skate (*Raia marginata*), one-sixth natural size. Recent. Britain. (After Gosse.)

ILY RAIIDÆ.—In the true or Skates (fig. 855) the broad and rhomboidal, ally has dermal rugosities; he rayed portions of the l fins extend to the com- ely short snout. The tail shorter than in the *Rhino-* with a longitudinal fold; development of the median ibject to considerable varia- The type genus *Raia* (*Actinobatis*) has the tail very distinct ne body (fig. 855); the pectoral fins not reaching to the ity of the snout; two dorsals, and either a rudimental or no fin. The dentition (figs. 856, 857) often varies greatly in the es; some or all of the teeth in the male being sharp, while all those of the female are obtuse. Some of these Skates measure upwards of seven feet across the disk. In a fossil state this genus occurs in the Chalk of the Lebanon, and the Upper Eocene of Hampshire; and also in the Suffolk Crags and Italian Pliocene, where it is represented by the living *R. clavata* (figs. 856, 857). The extinct *Dynatobatis*, from the Tertiary of South America, is distinguished by the enormously expanded bases and the small spines

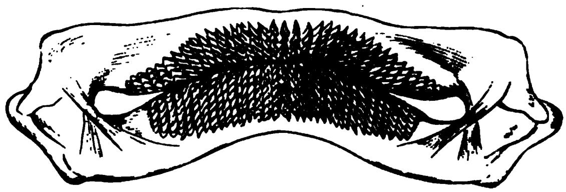


Fig. 856.—Front view of the jaws of the male Thornback Skate (*Raia clavata*). Reduced.

of the dermal tubercles with which the body is studded. *Acanthobatis*, from the Middle Miocene of France and Würtemberg, has tall dermal tubercles, with small bases, which often fuse together into

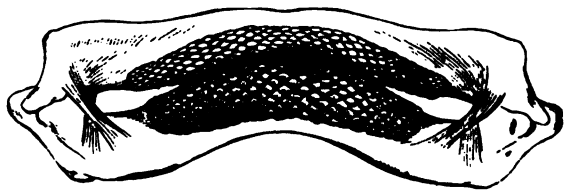


Fig. 857.—Front view of the jaws of the female Thornback Skate (*Raia clavata*). Reduced.

groups; while *Oncobatis* of the Pliocene of Idaho, which has these tubercles of a pentagonal form, may be identical with the type genus.

FAMILY TORPEDINIDÆ.—The Electric Rays have the disk broad and smooth; the rayed portion of the pectoral fins not continued beyond the base of the snout, and the median fins well developed. The peculiar electric organ is placed between the head and the pectoral fins. Extinct species of the existing genus *Torpedo* occur in the Middle Eocene of Monte Bolca, near Verona.

FAMILY PSAMMODONTIDÆ.—This extinct family is known only by portions of the dentition, so that its definition is at present impossible. It appears, however, from the parallelism of the mandibular rami that the body must have been depressed like that of the Rays. The teeth (fig. 852, 5) are of a flattened quadrangular form, with the root nearly as large as the crown, and were arranged in one or more longitudinal rows, which were arched antero-posteriorly with lternation of the teeth of adjacent rows. The genus *Copodus* nmetrical teeth, with the postero-lateral angles of the root, netimes also of the crown, produced backwards; the teeth arrowest in front, with the anterior margin usually either or convex. The crown surface when unworn is rugose, and by a more or less transverse line, which sometimes permits portions to be separated. This genus occurs in the Car-s of Europe. In the typical *Psammodus* the teeth (fig. re quadrangular, generally more or less oblong, but occa-nearly square, with the root much thicker than the crown, ch it is easily separable; the surface of the crown being marked by transverse wrinkles. It is probable that the e arranged in the jaws in four longitudinal rows. *Psam-* represented by a considerable number of species from the rous of both Europe and North America. Lastly, *Archæ-* om the Carboniferous of Indiana, is an allied form, with pavement-like teeth arranged in several rows, of which surfaces are somewhat excavated to fit the curvature of

MYLIOBATIDÆ.—With the Eagle-rays we come to an exist- well represented in a fossil state as far down as the Lower vertebræ from Cretaceous and Jurassic beds having been red to this family. The disk is very large, owing to the elopment of the pectoral fins, which stop short at the sides ad, but reappear at the extremity of t in the form of a small single or phalic fin. The tail is extremely and resembles a whip-lash; and the when present, forms a complete . The type genus *Myliobatis* has free from the disk, and a single fin. The teeth are large, flat, and l, and are arranged in seven longitu-s; the middle row in the adult being broad, while the lateral rows are aped (fig. 858). In the young the ow of teeth is not larger than the es, and there is a gradual increase in e breadth of this row as the fish in-age. The upper dental plate is ex-onvex from before backwards, but the e is quite flat. In addition to the vertebræ mentioned above, this genus is known continu-n the Lower Eocene upwards, and has a wide distribution in Thus, in the Eocene, it is recorded from Europe, India, and

Fig. 858.—Part of the lower dental plate of *Myliobatis striata*, from the Middle Eocene of Bracklesham, Sussex. Reduced. The second lateral rows of teeth are imperfect, and the third wanting.

North America; and it has also been described from the Tertiary of New Zealand. A very large number of specific names have been applied to the fossil forms, but Mr S. Woodward has shown that the number of valid species may be greatly reduced, since many of the characters on which they were founded are solely due to differences in the age of the specimens. In *Rhinoptera* (*Zygobates*), while the head is still free, there are two cephalic fins, and the teeth are arranged in five or more rows, of which the middle series and the adjacent pair are broad, while the one or two pairs on the borders form regular hexagons. This genus is known from the London Clay, the Eocene of South Carolina, the Swiss Miocene, and the English Crag, and is now represented by seven species from tropical and sub-tropical seas. The existing genus *Aëtobatis* is distinguished from the preceding by the teeth being arranged in only a single longitudinal row, which is often bent, and corresponds to the median row of *Myliobatis*. One species is found from the London Clay to the higher Eocene of Barton, and the genus is also represented in the Swiss Miocene. The existing genus *Ceratoptera* has no upper teeth.

In this family may be provisionally included the Cretaceous genus *Ptychodus*, which was long considered to be a Cestraciont Shark, but has been shown by Mr Smith-Woodward to be a Ray allied to *Myliobatis*. The connection between *Ptychodus* and the existing *Myliobatidæ* is shown by the genus *Apocopodon*, from the Upper Cretaceous of Brazil, which has teeth of an intermediate type; while some of the Eocene species of *Myliobatis* have teeth of nearly the same form as those of *Ptychodus*. The teeth of this genus (fig. 859) have quadrangular crowns, with the enamel of the central region thrown into a number of transverse folds, while the root is smaller and lower than the crown. The two sides of each jaw are parallel to one another, and the teeth are arranged in several parallel rows running from back to front, as is shown in the accompanying diagram (fig. 860). It will be seen, moreover, that each jaw has a single median series, composed of very small teeth in the upper, and of very large ones in the lower jaw; while on either side of this median row there is a series of teeth somewhat less large than the median row of the lower jaw. The five external rows gradually decrease in size towards the outer side of the jaws. A comparison

Fig. 859.—Oral and lateral views of the crown of a tooth of *Ptychodus polygyrus*, from the Upper Greensand of Regensburg. (After Zittel.)

with fig. 858 will show that the general plan of this arrangement of the teeth is essentially the same as in *Myliobatis*. This genus has a wide distribution, being found in the Upper Cretaceous of Europe, India, and North America.


Fig. 860.—Diagram of the arrangement of the teeth in the upper (A) and lower (B) jaws of *Ptychodus decurrens*. (After S. Woodward.) Reduced.

FAMILY TRYGONIDÆ.—In this family the pectoral fins continue to the extremity of the muzzle, with which they are confluent. The tail is slender, and sharply distinguished from the disk; while the vertical fins are imperfect or absent, and may be replaced by serrated spines. There is some uncertainty as to the occurrence of *Trygon* in a fossil state, but it is probable that either this genus or the allied *Tæniura* date from the Middle Eocene of Monte Bolca, and remains referred to the former have been described from the Upper Cretaceous of New Zealand. The extinct *Xiphotrygon*, from the Eocene of Wyoming, is distinguished by its cuspidate teeth. Remains referable to the existing tropical genus *Urolophus* occur in the Middle Eocene of Italy, and perhaps in that of Belgium; while *Cyclobatis* is an extinct genus from the Cretaceous of the Lebanon.

SECTION B. ASTEROSPONDYLI.—This section is distinguished from the last by having the radiating laminæ predominating over the concentric ones in the fully calcified vertebral centra, so that a section shows a star-like arrangement. The anal fin is always present; while specialisation does not tend to a flattening of the body, or to an expansion and forward growth of the pectoral fins, and the spiracles are small, and may disappear. This section comprises the true Sharks and the Dog-fishes.

All these fishes have elongated and subcylindrical bodies, and a strong tail, well adapted for swimming. The anterior, and very frequently all the teeth are formed on the type of a laterally compressed cone with trenchant edges, at the base of which two or more minor cones may be developed. In many cases, however, the hinder teeth have obtuse crowns, adapted for crushing. The two rami of the jaws are never parallel to one another, in consequence of which the teeth are always set in oblique rows (fig. 864), and never form the straight antero-posterior rows, like those occurring in the Rays (fig. 860). Sharks are carnivorous, and of active pelagic habits; and are most numerous in tropical seas, although they ascend tidal rivers, and are even found in an inland lake in the Fiji Islands.

This section may be divided into two series, in the first of which there is but one dorsal fin, and the number of the gill-clefts exceeds five.

FAMILY NOTIDANIDÆ.—The single family of this series is represented by the genera *Notidanus* and *Chlamydoselache*, both of which inhabit the warmer seas. The dorsal fin has no spine, and the teeth, of which several series are in use at the same time, have sharply pointed cusps. *Notidanus* (*Heptanchus*, *Hexanchus*) is readily

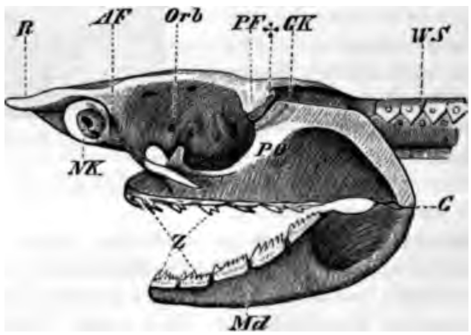


Fig. 861.—Left lateral view of the skull of *Notidanus*. Recent. Reduced. *R*, Rostrum; *AF*, *PF*, Pre- and postorbital processes; *Orb*, Orbit; *NK*, Nasal capsule; +, Articulation of palatopterygoid (*PQ*); *G*, Articulation of Meckel's cartilage (*Md*); *Z*, Teeth; *WS*, Vertebral column. (After Wiedersheim.)

characterised by the inferior position of the mouth and the peculiar form of the lateral teeth. These lateral teeth (figs. 861, 862) are comb-like, consisting of a series of compressed cones, inclined in one direction, and fixed upon an elongated base; the anterior cone being the largest, and frequently having cusps at the base of its anterior border. The lower teeth are more complex than the upper, and the anterior teeth in both jaws are simple and awl-shaped. The primitive position of this genus is shown by the persistent notochord and the characters of the skull (fig. 861). The latter approaches the so-called amphistylic type, differing from that of all other existing Selachians by the slenderness of the upper part of the hyoid arch, which does not support the palatopterygoid bar and mandible. The palatopterygoid is connected, however, with the cranium by a distinct facet articulating with the postorbital process. This structure is re-

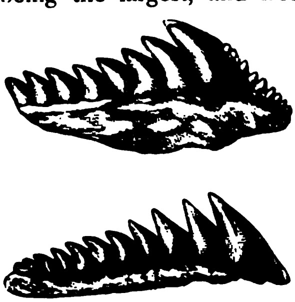


Fig. 862.—Lower teeth of *Notidanus gigas*; from the Red Crag. The anterior cusps are worn away in the lower figure. (After Smith-Woodward.)

garded by Mr Smith-Woodward as but very slightly removed from the original primitive condition; *Cestracion*, in which the hyomandibular becomes distinctly differentiated, being a step in advance. In time this genus is definitely known to range from the Middle Jurassic of the Oxford Clay to the present day; it has indeed been recorded from the Lias, but the determination is more than doubtful. Nearly all the described species are European, but one has been recorded from the Tertiary of New Zealand. Some of the fossil teeth show signs of wear at their summits, and it thus seems that they must have been firmly implanted in the jaws like those of the Hybodonts; specialisation having apparently tended to produce a loose dental articulation throughout the section. The genus *Chlamydoselache* has a terminal mouth, with lateral teeth similar in both jaws, and consisting of three slender cones separated by smaller cusps; the notochord being partly calcified. This genus is now known by a single living species from the Japanese seas, but teeth from the Pliocene of Tuscany have been referred to it. It will be observed from the figure that the mandibular articulation of *Notidanus* is placed far behind the cranium proper, and it is noteworthy that a similar condition obtains in *Pleuracanthus* among the Ichthyotomi.

FAMILY COCHLIODONTIDÆ.—With this family we enter the second series of the section, in which there are two dorsal fins and five gill-clefts. The present extinct family is an ill-defined one, apparently allied to the *Cestraciontidæ*, but with a more specialised dentition. The dentition is formed from that of the *Cestraciontidæ* (*infra*) by the welding of at least one of the oblique transverse rows of teeth encircling each ramus of the jaws into a continuous curved plate (fig. 863), which may have either a smooth crown-surface, or may be marked, as in the figured example, by grooves and ridges, indicating its compound origin. These dental plates grow by additions to their inner borders, while the outer borders are usually involuted. The dorsal fins were provided with spines. This family comprises a number of genera from the Carboniferous, only some of which can be very briefly noticed in this work. The one most imperfectly known is *Helodus*, from the English Carboniferous, which appears allied to the next, but does not seem to have had the teeth welded into plates, and therefore differs from the accepted definition of the family. *Pleuroplax* (*Pleurodus*) and *Psephodus* are more typical forms, the latter occurring both in Europe and North America. The dental plates of *Psephodus* form at least one series of smooth curved teeth, without coronal ridges or involution of the outer border; and there were also smaller rows of lateral teeth, as well as some prehensile teeth at the extremities of the jaws. *Sandalodus* is known by the huge dental plates, which are of an elongated triangular shape, with the outer border slightly involuted, and an undulating coronal contour in the upper jaw; the genus occurring in Europe and the United States. Other genera which can be merely mentioned are *Tomodus*, *Xystrodus*, *Deltodus*, and *Pœcilodus;* the three last being common to Europe and North America. Teeth referred to *Pœcilodus*, and to the above-mentioned genus *Psephodus*, have also been described from the Carboniferous of Northern India; and the teeth from the same beds described under the name of *Helodopsis* are likewise referable to the present family. In the type genus *Cochliodus*, of Europe and the United States, there are two pairs of dental plates in the mandible (fig. 863), in which the outer border is much involuted. The posterior plate is elongated antero-posteriorly, and has its anterior and posterior borders converging outwardly, and a prominent oblique ridge, likewise narrowing in the same direction, in the middle of the crown. The anterior plate is narrow from before backwards, with a ridge on the hinder border of its crown resembling the median ridge of the larger plate. The remaining genera of this family are *Streblodus*, *Deltoptychius*, *Diplacodus*, and *Cyrtonodus*, of which the two last are doubtfully entitled to distinction; while other names have been applied to detached anterior teeth.

Fig. 863.—Lower dental plates of *Cochliodus contortus;* from the Carboniferous of Armagh. One-half natural size. The specimen is viewed from the anterior aspect, and the white line on the left side shows the division of the two plates.

FAMILY CESTRACIONTIDÆ.—This family, which may be taken to include the *Orodontidæ* and *Hybodontidæ* of many writers, is represented by a considerable number of genera ranging from the Carboniferous to the present day; all the existing species being included in the type genus *Cestracion*, of which the upper dentition is shown in fig. 864. The family is characterised by the presence of a spine to each dorsal fin, of which the first is placed immediately above the interval between the pectoral and pelvic fins. The teeth are generally more or less obtuse, with several series in use at the same time, and those of each oblique series never fused into continuous plates. One of the oldest genera is *Orodus* (more correctly *Oreodus*), of the Carboniferous of Europe and the United States, in which the teeth are of the general type of those of *Hybodus*, and are only regarded by Mr S. Woodward as entitled to separation on account of the absence of other associated remains which are characteristic of the Mesozoic genus. It is probable that some of the dorsal fin-spines originally described under the name of *Ctenacanthus* belong to

Orodus. Most of these spines (fig. 852, 2) are, however, referable to the allied Carboniferous genus *Sphenacanthus;* and they are characterised by their ornamentation of robust longitudinal ridges,

Fig. 864.—Upper jaw of the Port Jackson Shark (*Cestracion Philippi*). One-half natural size. (After Owen.)

which are partly nodose. Other Carboniferous genera are *Campodus*, *Diclitodus*, and *Tristychius*, some of which have several synonyms. In the Thuringian Permian this family is represented by the genus *Wodnika*, in which the teeth have large and smooth crowns well

Fig. 865.—Tooth of *Hybodus varicostatus;* from the Lias of Dorsetshire. (After S. Woodward.)

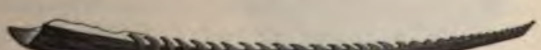


Fig. 866.—Imperfect fin-spine of *Hybodus* (*cf*) *basanus;* from the Lower Cretaceous. Reduced.

adapted for crushing; while in the Muschelkalk, or Middle Trias, we have the imperfectly known *Palæobatis*, with teeth very like those of *Asteracanthus*. With the genus *Hybodus*, ranging from the Muschelkalk to the Lower Greensand of Europe, we come to a type which is now almost as well known to us as existing Sharks, owing to the beautiful preservation of many of the specimens from the Lias, in which deposits these fishes were abundant. Many of the numerous species attained very large dimensions; and the genus may be defined by the following characters. The teeth (fig. 865) are conical or cuspidate, the crown being more or less striated, with one main cone, flanked by one or more lateral cones, and the root being more or less depressed. The teeth at the symphysis are large and few in number; while the fin-spines (fig. 866) are longitudinally grooved and ridged, with two rows of denticles placed near the posterior borders. The most remarkable feature is, however, the presence of two large hook-like spines immediately behind each orbit, which have been described under the name of *Sphenonchus*. The notochord is persistent.

Fig. 867.—Tooth of *Acrodus nobilis*, from the Lower Lias of Lyme-Regis.

Specimens of the Lower Liassic *H. Delabechei* show the whole of the dentition *in situ*; and it appears from these that there was no median symphysial row of mandibular teeth, but that there were ten transverse rows of lower teeth, with five teeth in each row, while the number of rows in the upper jaw was either nine or ten. In the later forms, such as *H. basanus* of the Wealden, the teeth differ from those of the typical Liassic forms by the taller, compressed, and nearly smooth crowns, and Mr Woodward suggests that it may eventually be advisable to refer these types to a distinct genus. The orbital hooks found in the Oxford and Kimeridge clay indicate fishes of very large dimensions.

Fig. 868.—Part of the palate of *Asteracanthus ornatissimus*, from the Great Oolite of Caen. Reduced. (After Owen.)

The genus *Acrodus* is closely allied to the preceding; but the teeth (fig. 867) are non-cuspidate and more rounded. This genus is abundant in the Lias, where it is represented by the large *A. nobilis*, which is the type; but it also extends downwards to the Muschelkalk, and ranges upwards as high as the Chalk. The majority of the species are European, but the genus has also been recorded from the Cretaceous of North America, as well as from certain beds in that country which have been stated to be Miocene.

teracanthus (*Strophodus*) agrees with *Hybodus* in the persistent hord and the presence of orbital spines, but differs in the cters of the fin-spines and teeth (figs. 868, 869). The prin- teeth form irregular rhomboids, with slightly arched and ned crowns, marked by a reticulate ornamentation—the sym- al teeth being large, few, and simple. The fin-spines are ed by stellate tubercles, which are sometimes fused, and two posterior mesial series of denticles. The type species 868) is of great size, and occurs typically in the Great e of the Continent and England, but ranges upwards to Kimeridge Clay, and thus presents a remarkable instance rsistence. This genus is also represented in the Purbeck. extinct genera are *Palæospinax*, from the Lias, and *Synech-* from the English Chalk, both of which have teeth closely bling those of *Hybodus*; he fin-spines, at least in ormer, were smooth, like of *Cestracion*. The Cre- us genus is the more lised, and approximates anial structure to *Noti-*, the palatopterygoid ar- ting directly with the im. Finally, the existing *Cestracion* (in which may cluded forms described the names of *Gyropleu-* and *Drepanophorus*) oc- n Europe from the Kim- an of Bavaria to the on Clay, and is now represented by four species in the alian and Japanese seas. This is a specialised genus differing *Asteracanthus* by the absence of orbital spines, the numerous mall symphysial teeth (fig. 864), the smooth fin-spines, and the lcification of the vertebral column.

Fig. 869.—Lateral and oral surfaces of a tooth of *Asteracanthus ornatissimus*, from the Corallian of the Continent. (After Zittel.)

MILY SCYLLIIDÆ.—This is a family of small extent, and most of nembers of which are of relatively small dimensions. The l fins have no spines, and the first is placed above or behind elvic fin; while the teeth are small and cuspidate, generally l series being simultaneously in use. The living forms are nonly known as Dog-fishes. *Palæoscyllium*, of the Lower Kim- ian of Bavaria, seems to be allied to the existing *Ginglymostoma* *Scyllium*. *Scylliodus*, of the English Chalk, is an imperfectly n form with teeth like *Scyllium*, but with vertebræ approximat- o *Lamna*. *Scyllium* itself is represented in the Cretaceous of

the Lebanon and in the Continental Miocene; while allied ex
genera are *Pristiurus*, from the Lower Kimeridgian of Bavaria,
Mesitia, from the Lebanon beds. Finally, the existing *Chil*
lium occurs in the Miocene of Würtemberg; while *Ginglymost*
of which some of the existing species attain a length of 12 fe
represented in the Eocene of Alabama.

FAMILY LAMNIDÆ.—This family comprises the largest of
Sharks, and is characterised by having the first dorsal fin pl
above the interval between the pectoral and pelvic fins,
without a spine. The teeth are
minate, and when fully adult
solid throughout. The earliest
which has been referred to this fa
is *Carcharopsis*, known by deta
teeth from the Carboniferous of Eu
and North America. The type g
Lamna, in which *Otodus* may b
cluded, comprises the existing
beagles, and has large lanceolate
(fig. 870) with basal cusps, but wi
marginal serrations. Teeth agr
with those of existing forms in
general contour are found in Eu
from the Lower Miocene (fig.
upwards, the so-called *L. acumi*
from the Chalk, belonging, how
to the next genus. In another group of this genus, formerly kı
as *Otodus*, the teeth (fig. 871) are distinguished by the great

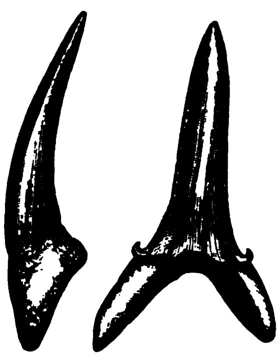


Fig. 870.—Tooth of *Lamna cuspidata*, from the Lower Miocene (Oligocene) of Germany. (After Zittel.)

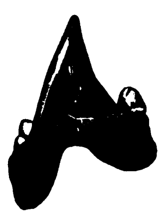


Fig. 871.—Tooth of *Lamna appendiculata*, from the English Chalk.

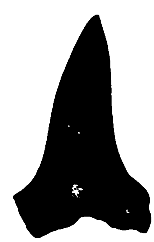
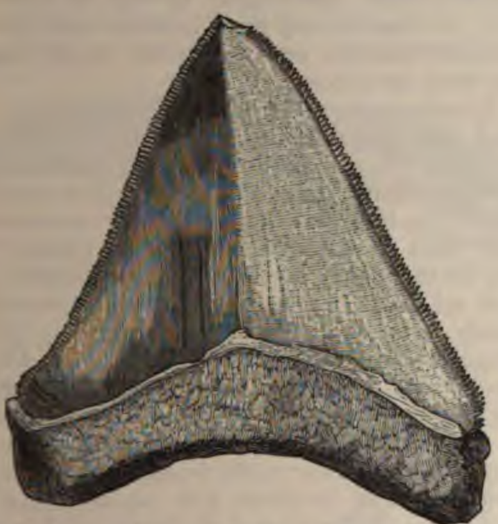


Fig. 872.—Tooth of *Oxyrhina plica* from the Hungarian Miocene.

pression of the crown, the large basal cusps, and the shortne
the root. Teeth of this type occur in Europe from the Ga
the London Clay, and are also represented in the Upper Creta
of Southern India and New Zealand. The nearly allied but e
genus *Oxyrhina* is characterised by the still greater compressi

crowns of the teeth (fig. 872), which are generally devoid of l cusps. It has been recorded from the Jurassic, and occurs ndantly in the Chalk of Europe, India, and New Zealand, and so represented in the European Miocene. Teeth from the r Cretaceous of Europe and India, differing from those of a by the nearly circular section of their crowns, have been ed to the existing genus *Odontaspis*; but Mr S. Woodward lers that they belong to a genus from the Cretaceous of the on, originally described under the preoccupied name of *Rhino-s*, but now known as *Scapanorhynchus*. *Odontaspis* itself in the Eocene. Teeth of a long and slender type, from the Jurassic and Lower Cretaceous, have been described under



73.—Tooth of *Carcharodon megalodon*, from the Miocene of Malta. (After Zittel.)

me of *Sphenodus*, now changed to *Orthacodus*. Other teeth, he Continental Miocene, have been referred to the existing *Alopecias* or "Threshers." With *Carcharodon* we come to of enormous size, characterised by their large, flat, and reg- triangular teeth (fig. 873), in which the edges are serrated, ere are no basal cusps. The one existing species attains a of 40 feet, and has teeth measuring a little over 2 inches the margins, with a basal width of 1.8 inches. It occurs fossil Pliocene of Europe. In the Red Crag, and also at the bottom Pacific, teeth are, however, found in which the corresponding sions are 5 and 4 inches, and thus indicate enormous individuals. Smaller teeth (fig. 873) also occur commonly in the Miocene of Malta, the Tertiary of New Zealand, and still smaller forms (fig. 874) in the Lower Miocene and Eocene of the Continent; and the genus is also represented in the Pliocene of Burma. Its earliest representative is, however, *C. longidens*, from beds which appear to be of the age of the Maastricht or topmost Cretaceous. Small compressed and triangular teeth, usually with serrated edges, from the Chalk of Europe and India, to which the name *Corax* has been applied, probably indicate Sharks allied to *Carcharodon*, although in external contour they approximate to the teeth of the next family: they have, however, solid crowns. The genus *Cetorhinus* (*Selache*), now represented by the huge Basking Shark, dates from the Pliocene.

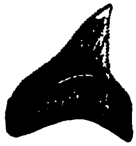


Fig. 874.—Tooth of *Carcharodon productus*, from the Lower Miocene of the Continent. Reduced.

FAMILY CARCHARIIDÆ.—The last family we have to mention is distinguished from the preceding by the presence of a nictating membrane to the eye, and also by the hollow crowns of the teeth. It is unknown before the Upper Cretaceous, and is dominant at the present day. The teeth have triangular and compressed crowns, usually with more or less distinctly serrated edges. The genus *Hemipristis*, of the Upper Chalk and Lower Tertiary, is characterised by its tall lanceolate teeth, the crowns of which have both edges coarsely serrated, except at their summits. The existing genus *Galeocerdo* is first recorded from the topmost Cretaceous of Holland, and occurs throughout the European and American Tertiaries from the Eocene upwards; the existing forms being known as "Topes." *Carcharias*, including the well-known Blue Shark, has small and generally triangular teeth, those of the upper being very different from those of the lower jaw. It may be divided into several groups from the structure of the teeth, which in some forms have smooth edges. It first occurs in the London Clay, and is thence found throughout the European Tertiary series; it has also been recorded from the Egyptian Eocene, and is found in the freshwater Pliocene Siwaliks of north-western India. The strange Hammer-headed Shark, the only representative of the genus *Sphyrna* (*Zygæna*), has teeth so closely resembling those of *Carcharias* that it is almost impossible to distinguish detached specimens. It appears, however, that there is sufficient evidence to prove the existence of a species of the former genus in the Miocene of Europe and of the United States.

ICHTHYODORULITES.—In conclusion, a brief notice may be given of a few of the numerous genera founded upon the so-called "ichthyodorulites" or spines, of which the serial position cannot at present be determined, and several of which are probably referable to the Chimeroidei. The earliest of these is *Onchus* (fig. 875, A), from the Silurian bone-bed of Ludlow, to which genus may also belong the dermal denticules (*ibid.*, B) described under the name of

Fig. 875.—Spine (A) of *Onchus tenuistriatus*, and (B) Dermal plates of *Thelodus*; from the Silurian of Ludlow.

Thelodus. In the Devonian of North America, and also in the Upper Silurian or Devonian of Bohemia, large spines have been described under the name of *Machæracanthus* (fig. 876), which probably belonged to the dorsal fins. *Gyracanthus* is based on

Fig. 876.—Fin-spine of *Machæracanthus major*; from the Devonian of North America. One-half natural size. (After Newberry.)

asymmetrical spines (fig. 852, 2), which, it has been suggested, may belong to the pectoral fins. Other Carboniferous specimens have been named *Lophacanthus* and *Oracanthus* (England), *Eu-canthus* (Russia), *Xystracanthus* (North America and India), and *haumatacanthus* (India). he spines described as *racanthus* are now known belong to the head of Selachian, and not, as first supposed, to the l of a Placodermic Ga-id. It will be un-cessary to mention a mber of other types m various deposits; but must not conclude thout referring to the markable specimens (fig. 7) from the Carboniferous of North America and Australia, to ich the name *Edestus* has been given. These have a highly rved axis, bearing compressed lancet-like teeth, with serrated edges

Fig. 877.—Part of (? caudal) spine of *Edestus vorax*; from the Carboniferous of North America. One-half natural size. (After Newberry.)

either on the convex or on both borders. It is suggested that they may have been carried on prominences in the caudal region. And after describing the best preserved remains of this genus, Dr Newberry concludes as follows: "Hence, until further light shall be thrown upon the interesting question of the homologies and functions of [the remains of] *Edestus*, we may regard them as the post-dorsal spines of large cartilaginous fishes, of which the other parts are yet unknown, and may suppose that they were used for attack and defence, like the spines of *Trygon* or *Acanthurus*."

Spines of similar type from the Carboniferous of Russia, originally described as *Edestus protopirata*, have been subsequently made the type of the genus *Protopirata*, although it is doubtful whether this term, having been first made a specific one, is admissible as a general one.

CHAPTER XLVIII.

CLASS PISCES—continued.

Orders Chimeroidei and Dipnoi.

Order III. Chimeroidei.—The Chimæroids are marine fishes, regarded by some writers as a suborder of Elasmobranchei; but although they resemble Sharks in external contour, in the presence of "claspers" on the pelvic fins of the male, and in the structure of the egg-capsules, yet they present such important differences as to indicate the propriety of referring them to a distinct order. The skeleton is entirely cartilaginous, and the vertebral column only imperfectly segmented; the notochord being surrounded by a series of cartilaginous rings, which may be partly calcified. The skin of the typical forms is usually quite naked in the adult, but in the young there is a row of small dermal ossifications on the back. The skull is movably articulated to the vertebral column, and has the hyomandibular fused with the palatopterygoid bar, and the latter firmly united to the cranium, with which the mandible consequently articulates without the intervention of a separate suspensorium—this arrangement being termed *autostylic*. The gill-clefts are four in number, and protected by a fold of skin containing a cartilaginous gill-cover; their communication with the exterior being effected by a single aperture. The mouth is always terminal; and in the recent forms each jaw carries one pair of molariform teeth, respectively attached to the palatopterygoid and Meckel's cartilage (mandible), with the addition of a smaller anterior pair of vomerine cutting-teeth in the upper jaw—all these teeth persisting throughout life. The fins are similar in structure and position to those of the Sharks; the first dorsal always carrying a strong spine, which articulates with the neural spines of the vertebræ, and is thus susceptible of motion. In the absence of a swim-bladder the Chimeroids, again, agree with the Elasmobranchs. There is a lateral line strengthened by cartilaginous rings. From the absence of any membrane bones, the massive teeth, which are strictly comparable to those of the Dipnoi, constitute the whole of the solid part of the jaws.

This order may be regarded as in some respects connecting the Elasmobranchs with the Dipnoi—the autostylic cranium and the dentition being essentially Dipnoid. Chimæroids have existed from the Lias upwards, and not improbably date from the Devonian; while, as is usually the case, some of the extinct genera show much more generalised affinities than their existing representatives.

FAMILY SQUALORAIIDÆ.—The extinct genus *Squaloraia* was long regarded as an Elasmobranch of somewhat uncertain affinities; but according to the observations of Dr Traquair, it should find a place in the present order. In this genus, which is confined to the Lias, there is an elongated body; while the skull is produced into a long flat rostrum, and carries a basal pair of teeth separated at the symphysis, in advance of which are two small vomerine teeth of the normal Chimæroid type. Further, the skull of the male has a prehensile spine on the upper part of the snout, resembling in structure that found in *Ischyodus*. The "lateral line" agrees with that of other Chimæroids in being open, and protected by cartilaginous rings; while the skin appears to have been entirely naked. The vertebræ are of the Tectospondylic type of those of the Rays. The skull has been described as hyostylic, but Dr Traquair considers that this is due to crushing, and that it is really of the autostylic structure.

FAMILY CHIMÆRIDÆ.—Nearly all the remaining forms, from the Lias upwards, may apparently be included in this family, which is now represented by *Chimæra* and *Callorhynchus*. The teeth are of enormous size, those of opposite sides meeting in a median symphysis; and each tooth has one or more triturating ridges, or prominences, differing in appearance from the rest of the tooth, which may be conveniently termed *tritors*. The type genus *Chimæra* has the teeth adapted for cutting; those of the mandible being thin and plate-like, with one large median tritor, and two tritors near the anterior extremity, and an outer series in the form of dots; while the palatal tooth varies considerably in shape. This genus is represented at the present day by three species, and has also been recorded from the Pliocene of Italy and the Miocene of Bavaria. In *Elasmodectes* (*Elasmognathus*) of the English Chalk, the mandibular teeth are likewise of a cutting type, but without the median tritor. The extinct *Ischyodus*, which in England ranges from the Upper Jurassic to the Chalk, but has also been recorded from the Eocene of North America and the Cretaceous of New Zealand, appears to connect *Chimæra* with the next genus; the teeth being more adapted for crushing. The mandibular teeth are, indeed, more massive, and generally have two well-marked tritors externally to the large median one; while there is a spine on the rostrum. *Edaphodon*, which ranges from the Lower Greensand to the Middle Eocene of Bracklesham, like the last genus, attains gigantic dimensions, but has its teeth adapted entirely for crushing. The mandibular tooth (fig. 878) is very massive, and has its symphysial surface (which in the preceding genera is narrow and grooved) very wide and quite flat, while there are two outer and one median tritors, as well as a terminal tritor which is not shown in the figure. Each palatal tooth is furnished with three tritors. Teeth of this genus are common in several Cretaceous and Tertiary deposits. *Elasmodus*, which is found in the Lower and Middle Eocene of England, appears to be

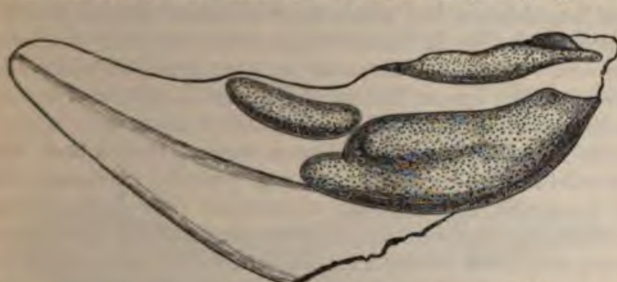


Fig. 878.—Inner surface of the right mandibular tooth of *Edaphodon gigas*; from the English Chalk. Reduced. (After Egerton.)

allied to the preceding genus; while in the existing *Callorhynchus* we apparently have the most specialised representative of the group with crushing teeth. The latter genus is represented by an existing species in the Southern seas, and by a fossil one from the Lower Cretaceous of New Zealand. The mandibular tooth is massive, with a narrow symphysis, and only a single tritor, representing the large median one of *Edaphodon*. Other European forms are *Ganodus*, from the Lower Jurassic of Stonesfield, in which the tritors of the mandibular tooth are confluent; and *Myriacanthus* (*Prognathodus* or *Metopacanthus*), of the Lower Lias of Dorsetshire, which is known both by the spines and the teeth. Its premaxillary teeth are chisel-like in shape. *Leptacanthus* of the Lias, and *Dipristis* of the Middle Miocene, are imperfectly known forms probably referable to this family. In North America the names *Eumylodus*, *Leptomylus*, *Byactinus*, *Diphrissa*, *Isotænia*, and *Sphageopœa* have been applied to Cretaceous forms, while a Miocene type has been called *Mylognathus*; but there is considerable doubt whether all these forms are really distinct from European genera.

As genera of which the family position is uncertain may be mentioned *Chimæropsis* from the Lower Kimeridgian of Bavaria, which differs from existing forms by its shagreen skin, and apparently also by the presence of a remarkable spine-like tooth placed in front of the normal tooth of the mandible. The fin-spines of this genus approximate to those of the Elasmobranchian genus *Asteracanthus*. *Rhynchodes* from the Devonian of Ohio, and *Ptyctodus* from that of both Russia and Illinois, are genera founded upon teeth which their describers refer to this order. Some of the genera founded upon the evidence of detached fin-spines, a few of which are noticed in the preceding chapter, should perhaps also find a place among the Chimæroids.

Finally, the genus *Cœlorhynchus* may be mentioned in this connection. It was founded upon spines originally regarded as the rostra of Sword-fishes, but which are evidently of dermal origin, and are considered by Mr S. Woodward as being probably fin-spines of Chimæroids. These spines occur in the Chalk of England and Maastricht, in the Lower Eocene of England, Egypt, and India, and also in the Middle Eocene of Bracklesham in Sussex.

ORDER IV. DIPNOI.—The Dipnoi, which Dr Günther regards as a subdivision of the Ganoidei, are typically freshwater fishes, usually presenting the following characters: The body is covered with imbricating cycloidal scales, while the vertebral column is cartilaginous, and there are both anterior and posterior nostrils placed more or less within the mouth (fig. 881). The primitive cartilaginous cranium persists more or less completely, and, like that of the Chimæroids, is autostylic; cranial membrane bones are, however, always developed to a certain extent, and there are also splenial and articular bones in the mandible, while the cranium is immovably connected with the vertebral column. The palatopterygoid bar persists as the functional upper jaw, and, as in the living Chimæroids, carries a single pair of molariform teeth, while a corresponding pair of teeth are placed on the splenial and articular bones of the mandible. There is also a smaller pair of vomerine teeth; in advance of which there may be other minute teeth. The paired fins have a long, cartilaginous, jointed, median axis (fig. 845), and the tail may be either diphycercal or heterocercal. There are no functional branchiostegal rays; and the five or six cartilaginous branchial arches are more or less rudimentary, and their single aperture is closed by a gill-cover. The teeth agree with those of the Chimæroids in having no successors; but, from the presence of membrane bones, do not constitute the whole of the jaw.

In the structure of their skull the Dipnoi show affinities to Chimæroids, Ganoids, Teleosteans, and Amphibians; the autostylic feature connecting them with the former, and the double nares with the latter, in which the skull is also autostylic. The lungs are formed by the connection of the swim-bladder with the gullet by means of a duct, and these fishes can thus either breathe by means of their gills in water, or by their lungs on land. In the existing African *Protopterus* there are external branchial tufts, like those of the young of the Amphibia. The structure of the pelvic girdle and limbs has been already noticed in the introductory chapter on the lass; but it may be observed that although the skeleton is essenially cartilaginous, yet imperfect ossifications may occur in the eural spines of the vertebræ, as well as in the ribs and fin-rays. he scales may be either ganoid or cycloid.

That this order is essentially an old one, may be inferred not ly from the widely scattered distribution of the three existing nera, and their paucity in species, and sometimes in individuals; t also from the generalised structure of its members, and the currence of one of the existing genera in the Trias of Europe, and reputed Permian of North America.

FAMILY LEPIDOSIRENIDÆ.—This family is only known by two sting genera, and is characterised by the persistent chondronium, carrying a few large membrane bones, by the cycloid scales,

Fig. 879.—*Lepidosiren paradoxa*, from South America. Reduced. *p*, Pectoral; *v*, Pelvic fin.

absence of jugular plates, the continuous vertical fin, and the rrow central axis of the paired fins, which are reduced to filaments. e two genera are *Lepidosiren* (fig. 879) of the Amazons, in which paired fins are not fringed; and *Protopterus* of the rivers of pical Africa, where those fins are furnished with fringes. There

Fig. 880.—The Barramunda (*Ceratodus Forsteri*), from Queensland. Reduced.

e two small conical vomerine teeth, and larger cuspidate teeth the palate, while the body is eel-like.

FAMILY CERATODONTIDÆ.—The genus *Ceratodus* (fig. 880) has en generally placed in the same family as the preceding forms, with ich it agrees in the continuous vertical fin, the cycloid scales, the sence of jugular plates, and the few cranial bones. In many respects, and more especially as regards the dentition, *Ceratodus*, as pointed out by Dr Fritsch, is, however, much more nearly allied to the under-mentioned family *Dipteridæ*, and it seems advisable to regard it as representing, at least provisionally, the type of a distinct family.

Ceratodus is one of the very few instances where a genus, founded upon the evidence of fossil specimens, has subsequently been discovered in a living condition. Fossil teeth of this genus were long known, but it was not until the year 1870 that the existence of a living representative was brought to the notice of science. The body of the Barramundas, as these fishes are termed, is laterally compressed, with one continuous vertical fin; while the paired fins are paddle-shaped, with a broad fringe. The vomerine teeth (fig. 881, *x*) are shaped like the incisors of many mammals, while those on the palate (*ibid.*, *xx*) and mandible have an inner smooth convex border, and externally bear a number of strongly-marked ridges or horns. In the existing species the teeth of opposite sides are separated by a distinct interval (fig. 881), but in some fossil forms they were in contact. Again, in the living species, the palatal teeth bear six distinct horns, while the backward production of the inner margin forms an incomplete seventh horn (fig. 881); but in the mandibular teeth there are not more than the typical six horns. In fossil forms, according to Professor Miall, the mandibular teeth are slightly smaller and narrower than the palatal ones, and have not more than four horns; while the palatal teeth have either five horns, or four and a rudiment of a fifth (fig. 882); this simpler structure of the teeth in the earlier forms being analogous to that which we have already mentioned as obtaining in the Selachian *Notidanus*. Some of the fossil teeth indicate individuals of two or three times the size of the Barramunda, of which the largest specimens attain a length of nearly six feet. The position of these upper teeth on the palatopterygoid bar is well shown in fig. 881, which also ex-

Fig. 881.—Mouth of *Ceratodus Forsteri*. Reduced. x, Vomerine; xx, Palatal; xxx, Mandibular teeth; *n*, anterior; *n'*, Posterior nares.

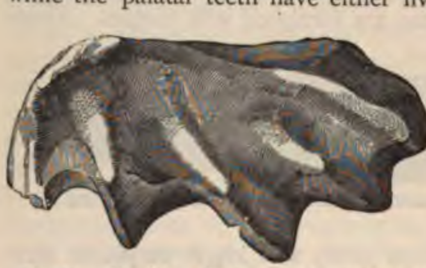


Fig. 882.—The right palatal tooth of *Ceratodus Hislopianus*, from the Lower Gondwanas of Maleri, India. The left side is the anterior border.

hibits the large parasphenoid, and the anterior and posterior nares. In regard to its distribution in past times, we meet with remains of this genus in the Jurassic of Colorado and Montana in the United States, and also in the Lower Jurassic of Stonesfield near Oxford; it is, moreover, abundant in the Upper (Keuper) and Middle (Muschelkalk) Trias of Europe, and has been recorded from the Lower division (Bunter) of that formation; it also occurs in Illinois in beds, which are thought to be probably Triassic; while in India teeth are very common in the Maleri group of the Gondwana system of the Central Provinces, which is not improbably also of Triassic age. Further, Professor Cope has recorded the genus from strata in North America identified by him with the Permian; but the species from the European Permian originally referred to this genus belongs to *Ctenodus*.

FAMILY PHANEROPLEURIDÆ.—In this family, which has been placed by some in the Crossopterygian Ganoids, we still have the

Fig. 883.—*Phaneropleuron Andersoni*; from the Devonian of Scotland, one-half natural size. A, Scale magnified.

continuous vertical fin, the diphycercal caudal fin, and the narrow axis of the paired fins characteristic of the preceding families; but the scales are said to have a ganoidal structure, jugular plates are present, and there is a series of minute teeth in the margins of the jaws. This family is typically represented by *Phaneropleuron* (fig. 883), of the Devonian and Carboniferous of Scotland and the Devonian of Canada, and the allied *Uronemus* of the Scottish Carboniferous. We may, however, here mention the genera *Megapleuron*[1] and *Conchopoma* from the Permian of the Continent, which should probably find a place in this or an allied family. The former genus has

[1] The rhomboidal scales which have been described as belonging to this genus are those of a Ganoid. The name should properly be *Megalopleurum*.

ossified ribs, large operculars, and Dipnoid teeth, but the form of the fins and tail is unknown; while the latter agrees with *Phaneropleuron* in the structure of the teeth and tail.

FAMILY DIPTERIDÆ.—This family is characterised by the great development of the cranial bones, the more or less ganoidal structure of the scales, the presence of jugular plates, the heterocercal tail, the two distinct dorsal fins, and the greater size and breadth of the scaled portion of the paired fins. Its range extends from the Devonian to the Permian, and it shows signs of connecting the preceding family with the Crossopterygian Ganoids. The teeth (fig. 885) are of the same general type as those of *Ceratodus*, but may carry a larger number of smaller ridges, which in some instances (fig. 885, 1, 2) are ornamented with a number of cusps or denticules. The typical genus *Dipterus* (fig. 884) comprises fishes of small or medium size, with circular scales, and both the dorsal fins placed in the hinder third of the body, the first being much smaller than the second. The pectoral fins are long and paddle-

Fig. 884.—*Dipterus Valenciennesi*; from the Devonian of Russia, two-thirds natural size. (After Pander.)

shaped; while the pelvic pair, and the anal, are respectively placed beneath the first and second dorsals. The quadrate is ossified; and there are also ossifications in the fin-rays and ribs. The teeth (fig. 885, 1) carry numerous denticules on their ridges. This genus is characteristic of the Devonian (Old Red Sandstone) of Europe. *Ctenodus* attains considerably larger dimensions than the preceding genera; some of the species reaching a length of nearly five feet. The teeth are characterised by their ridges carrying many cusps; and the scales are large and thin, with a rhomboidal contour, and bearing traces of rows of denticules, with vascular grooves on the inner side. The skeleton closely resembles that of *Ceratodus*, but is more fully ossified; and both this feature and the more numerous cranial bones are regarded by Dr Fritsch as characters of greater specialisation. The teeth (fig. 885, 2, 3) are frequently simpler than those of *Dipterus*, and thus approximate to those of *Ceratodus*; while the form of the parasphenoid and palatopterygoid differs considerably from that in the former. This genus ranges in Europe from the Carboniferous to the Permian, being very abundant in the former; and it is also recorded from strata in Illinois and Texas which are correlated with the European Permian.

As members of this order, but perhaps indicating one or more distinct familes, we may class the following genera: *Palædaphus*, from the Devonian of Europe and Ohio (the species from the latter area having been separated as *Heliodus*), is a moderately large form in which the mandibular teeth (fig. 885, 4) are very broad, and carry

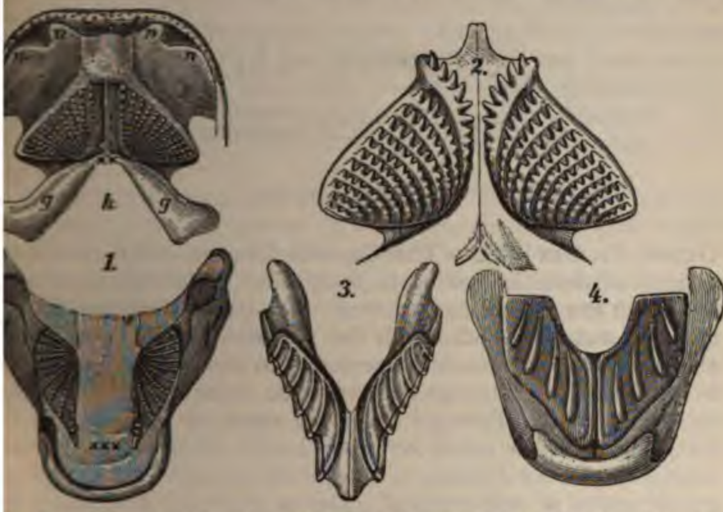


Fig. 885.—1, Upper and lower jaws of *Dipterus Valenciennesi*; from the Devonian. xx, latal; xxx, Mandibular teeth; *n*, *n*, Narial processes; *g*, Palatopterygoid. 2, Palate of *nodus tuberculatus*; Carboniferous. 3, Mandible of *Ctenodus imbricatus*; Carboniferous. Mandible of *Palædaphus insignis*; Devonian. All reduced.

ly four low ridges. *Holodus*, from the Devonian of Russia, is a aller form very imperfectly known, but apparently allied to the eceding; while *Conchodus* is known by teeth from the same desits in both Scotland and Russia. *Ganorhynchus*, of which the rizon is unknown, may also be provisionally placed here. From orth America we have *Ptyonodus* and *Gnathorhiza* from the Perian, and *Mylostoma* from the Devonian, of which the full affinities quire further elucidation.

CHAPTER XLIX.

CLASS PISCES—continued.

ORDER GANOIDEI.

ORDER V. GANOIDEI.—The Ganoids form an order exceedingly difficult of definition, owing to their close connection on the one hand with the Dipnoi and (through the Acanthodea) the Elasmobranchei, and on the other with the Teleostei, and it is not improbable that it may be eventually necessary to divide them into at least two orders. As mentioned above, some writers group them in a subclass with the Teleostei under the name of Teleotomi. The body may be either naked or covered with shagreen skin, or with large detached bony scales, or completely covered either with true ganoid scales, or with cycloidal scales of a ganoid structure. The vertebral column, again, may be either cartilaginous or fully ossified; and its termination in the tail may be either diphycercal or heterocercal. Paired and median fins are generally present, and the pelvic pair (with perhaps one exception) is abdominal in position. The skull may either be covered merely by cranial membrane bones, or may be completely ossified. It is hyostylic—*i.e.*, there is a hyomandibular suspensorium—and the palatopterygoid is distinct from the cranium; and, as a general rule, even in the cartilaginous forms maxillæ and dentary bones, which carry the teeth, are developed on the palatopterygoid and Meckel's cartilage respectively. The gills are usually free, and their single aperture is covered by an operculum; while branchiostegal rays are very generally present. In most cases a secondary pectoral girdle of dermal bones (clavicular, supraclavicular, &c.) is developed externally to the cartilaginous scapulo-coracoidal girdle, which alone exists in the preceding orders. Finally, there is a swim-bladder, with a duct into the pharynx; while there are some other characters of the soft parts into the consideration of which it will not be necessary to enter in this work.

Some very curious features occur in the ossification of the ver-column of certain members of this order which call for notice. Thus in *Eurycormus* the ossifications in the dorsal onsist of an upper and a lower hollow, wedge-shaped, semi- , with their pointed extremities interlocking, and the former the neural arches and the latter the ribs; while in the tail two centra to each neural arch. From this it would appear pieces bearing the ribs in the dorsal region, and the caudal hich have no arches, correspond to the intercentra of the ia, which are noticed below. The teeth of Ganoids vary n structure, and may be either conical and borne on the of the jaws, when they are continuously replaced, or flat- sks attached to the vomer, which have no successors. The of the fins are frequently furnished with the modified scales s fulcra.

derable diversity of view has prevailed as to the classification ids; but the system of Dr Traquair, who has paid especial to the structure of the order, is adopted in this work.

gards their distribution in time, Ganoids first appear in the nearly at the same time as the Elasmobranchs; and from onian to the close of the Mesozoic they form a very large on of the Fish-life of those periods. Their wane, however, to have set in during the Upper Cretaceous, when the i began to be numerically strong; and from that date there n a rapid decrease to the present day, when we find only the suborders (Amioidea) represented by several genera; the other three surviving suborders one is represented by era, and each of the other two by a single genus—these four ach having a solitary species.

ROGANOID SERIES.—The first three suborders may be con- y grouped in a single series, and are mainly characterised by ceedingly low development, their affinities being still doubt- rofessor Cope is indeed disposed to regard one of these rs (Placodermata) as more nearly allied to the Tunicata other Vertebrata; but this view is scarcely likely to find ion with the majority of palæontologists.

RDER I. CEPHALASPIDEA.—The members of this extraor- group have the head and the anterior part of the body with a continuous shield, while the rest of the body is vith small angular plates or scales. No traces of an inner , lower jaw, or teeth, have yet been discovered; but at least econd family there was a strong pectoral fin at the hinder y of the dorsal shield. The latter has been recently shown urnished with a system of sensory canals. This group is l to the Silurian and Devonian; and it is suggested by Pro- Iuxley that it may be allied to the Acipenseroidea.

Family Pteraspididæ.—The entire body in this family is unknown; but the dorsal shield (figs. 886, 887) is usually composed of several pieces united together, and has its borders thickened and

Fig. 886. — Imperfect dorsal shield of *Cyathaspis Banksi*; from the Silurian of Ludlow. (After Murchison.)

Fig. 887. — Dorsal shield of *Pteraspis rostrata*; from the Lower Devonian of Hereford. Reduced. (After Lankester.)

bent, and in structure approaches the scales of Teleostean Fishes. It has a median posterior spine, and sometimes small lateral cornua. There is also a small shield on the ventral aspect of the fish, which, like the dorsal one, is marked by fine striations. In the type genus *Pteraspis*, the dorsal shield (fig. 887) is shaped like an arrow-head, and composed of seven pieces; while in *Cyathaspis* (fig. 886) it is oval, composed of only four elements, and has the posterior spine very short. *Scaphaspis* has been founded on

Fig. 888.—Reduced restoration of *Pteraspis*.

remains belonging to these two genera, which are found in both the Silurian and Devonian; the simple shields described under this name having apparently been placed ventrally beneath the more complex ones, on the evidence of which the other genera were founded. *Holaspis*, from the Lower Devonian of North Wales, is distinguished by the dorsal shield, consisting of only a single element. Figure 888 is an attempt to restore the form of the type genus.

FAMILY CEPHALASPIDIDÆ.—The Cephalaspids are regarded by some writers as belonging to the *Pteraspididæ*, while by Professor Zittel they are placed in a distinct suborder. The dorsal cephalic shield (fig. 889) consists of one or two pieces, and usually has more or less developed lateral cornua, with a regularly curved and flat lower border—the eyes being situated near the middle; in structure it resembles true bone. The body is covered with bony plates, and the caudal fin is heterocercal. The typical genus *Cephalaspis* (figs.

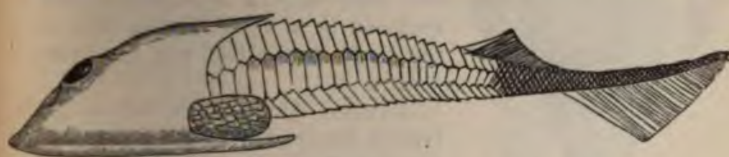


Fig. 889.—Left lateral view of *Cephalaspis Lyelli*; from the Devonian of Scotland. About one-third natural size. (After Lankester.)

889, 890) has the cephalic shield single, and may be divided into the *Eucephalaspidine* and *Hemicephalaspidine* groups, according to the degree of development of the cornua. It occurs in the Silurian and the Devonian of Britain, and has also been obtained

Fig. 890.—Smaller views of *Cephalaspis Lyelli*. (After Page.)

from the Silurian of Bohemia and the Devonian of Canada. *Xenaspis*, from the same English formations, is distinguished by the presence of one or more quadrangular dorsal plates behind the head; while *Auchenaspis*, of the European Silurian, has the cephalic shield transversely divided. *Didymaspis*, from the same formation, agrees with the latter in its double cephalic shield, which is, however, unprovided with cornua; while other genera are *Thyestes* and *Tremataspis*, from the Silurian of Russia.

SUBORDER 2. PLACODERMATA.—This suborder is mainly characteristic of the Devonian, although represented also in the Silurian, and lingering on till the Permian. It is characterised by the cartilaginous vertebral column, and the enclosure of the head and the anterior part of the body in bony plates, which are covered with a radiate or granular sculpture; the tail being either naked or clothed with scales. There is a distinct mandible; teeth are frequently present; and there may be a jointed pectoral fin enclosed in a bony covering like that of the body, but pelvic fins are invariably absent.

Fig. 891.—Reduced restoration of the dorsal aspect of *Asterolepis ornata;* from the Devonian of Russia. The tail is restored from *Pterichthys*. (After Pander.)

FAMILY ASTEROLEPIDIDÆ. — In the typical family the head (figs. 891, 892) is rounded anteriorly, and covered with a number of small thin plates; while the body is sub-quadrangular and invested with larger plates, some of which are median and others paired; and the tail may either be covered with much smaller scales or naked. There is a well-developed pectoral limb, which articulates with the anterior ventro-lateral plate; although it was long thought to articulate in some forms to a separate thoracic plate. The type genus *Asterolepis*, which occurs both in Russia and Scotland, is characterised, according to Dr Traquair, by the anterior median dorsal plate overlapping both the anterior and the posterior dorso-laterals, and by the somewhat depressed body. In *Pterichthys* (figs. 892, 893), on the other hand, the median dorsal plate, while overlapping the anterior dorso-laterals, is itself overlapped by the posterior dorso-laterals, and the body is much more elevated. This genus has been recorded from Scotland and the Eifel, and probably also occurs in Russia. Detached pectoral fins of these genera have been described under several names, and were at one time regarded as ichthyodorulites.

The genus *Bothriolepis*, from the Devonian of Europe and Canada, is distinguished by the different contour of the cephalic plates, and of the grooves of the lateral line system by which they are marked, as well as by the shorter limbs. No traces of the scaly tail have been observed in any of the known specimens, although

Dr Traquair considers that this appendage was probably present. Some of the species attained very large dimensions.

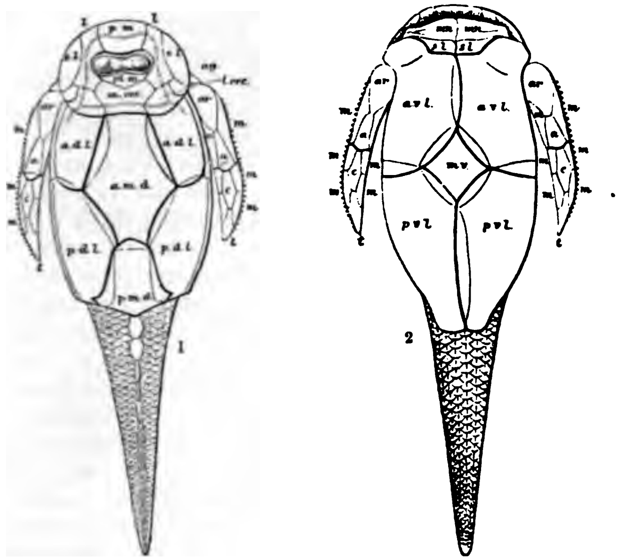


Fig. 892.—Reduced restoration of the dorsal (1) and ventral (2) aspects of *Pterichthys cornutus*, with the sculpture omitted; from the Devonian of Scotland. The thin black lines indicate the concealed edges of the overlapped plates, and the double dotted lines the grooves of the lateral line system. *m.occ*, Median occipital plate; *l.occ*, Lateral do.; *ag*, Angular plate; *pt.m*, Post-median do.; *p.m*, Premedian do.; *l*, Lateral do.; *e.l*, Extra-lateral do.; *mn*, Mental do.; *s.l*, Semilunar do.; *a.m.d*, Anterior median dorsal do.; *p.m.d*, Posterior do. do.; *a.d.l*, Anterior dorso-lateral do.; *p.d.l*, Posterior do. do.; *a.v.l*, Anterior ventro-lateral do.; *p.v.l*, Posterior do. do.; *m.v*, Median ventral do.; *ar*, Articular plate of limb; *a*, Anconcal of do.; *c*, Central of do.; *m*, Marginal of do. (After Traquair.)

Microbrachius, of the Scottish Devonian, is an allied form distinguished by the smaller size of the pectoral limb; in this form also

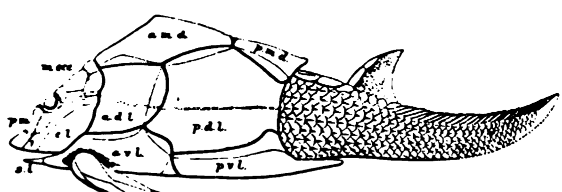


Fig. 893.—Reduced left lateral aspect of *Pterichthys cornutus*; from the Devonian of Scotland. Letters as in the preceding figure. (After Traquair.)

no caudal scales have been observed. The length of the head and carapace in the one known species is one and a quarter inches.

FAMILY COCCOSTEIDÆ.—The genus *Coccosteus* differs so markedly from the members of the preceding family that Dr Traquair has suggested that it should form the type of a distinct suborder. The head has distinct bones and plates differing markedly in their arrangement from those of the preceding family, but their structure has only recently been rightly explained (fig. 894). In the restoration given by Agassiz (fig. 895), although the arrangement of the posterior plates is fairly correct, yet anteriorly the grooves of the lateral line were mistaken for sutures; while the ethmoidal bones at the muzzle and the orbital notches are omitted. An approximation to a correct restoration of the lateral aspect is shown in fig. 896, but the mouth is made too long. The carapace, or body-shield, consists of a long shield-shaped middle dorsal plate, flanked by lateral plates, and completed by a median ventral plate. The posterior half of the body is totally unprotected, but interspinous bones in the vertebral column support an anal and a

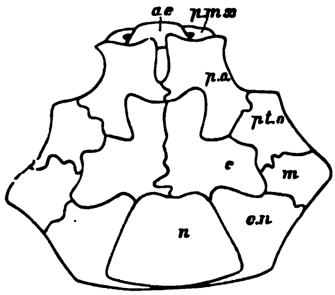


Fig. 894.—Dorsal aspect of the cranium of *Coccosteus decipiens*; from the Devonian of Scotland. *ae*, Ethmoidal, with nares of either side; *p.m.x*, Premaxilla; *p.o*, Preorbital, external to which is the orbit; *pt.o*, Postorbital; *c*, Central, *m*, Marginal, *n*, Middle occipital; *e.n*, Lateral do. (After Traquair.)

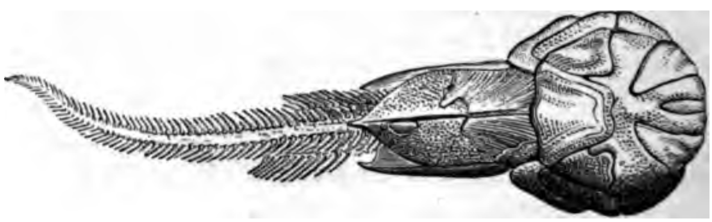


Fig. 895.—Dorsal view of *Coccosteus decipiens*, as restored by Agassiz. In the anterior part of the head the ethmoids and orbits have been omitted, and the black lines mostly indicate the grooves of the lateral line system, and not sutures. The shield-shaped plate immediately behind the skull is the middle dorsal, in advance of which is the middle occipital of the skull.

dorsal fin. There appears to have been no pectoral fin, although certain forms which have been generically or subgenerically separated as *Brachydirus* have been represented with such an appendage. Both this and the next genus are characteristic of the Devonian, *Coccosteus* being common to Europe and Canada. The allied *Homosteus* includes gigantic forms from Scotland and the Eifel, readily distinguished by the form of the cranial and body plates. Thus the middle occipital plate is longer and narrower, and the middle dorsal wider than long, and not pointed behind. Professor Huxley compares the armour of the Coccosteans to that of the Siluroid Teleosteans; while Newberry and Pander compare the ventral armour with the plastron of the Chelonia and Labyrinthodontia, with

Fig. 896.—Approximate restoration of the right lateral aspect of *Coccosteus decipiens*. Here the ethmoids and orbits are introduced, but the skull and mouth are made too long.

which, however, they also compare the true pectoral girdle of the Sauropterygia. The nature of the dentition is unknown.

FAMILY DINICHTHYIDÆ.—The genus *Dinichthys*, from the Devonian (Huronian) of North America, may probably be regarded as forming the type of a family allied to the preceding. In this genus, of which the type species has an estimated length of from 15 to 18 feet, the dentition (fig. 897) is remarkably like that of the Dipnoid

Fig. 897.—Diagrammatic anterior aspect of the jaws of *Dinichthys Hertzeri*; from the Devonian of North America. One-twelfth natural size. (After Newberry.)

genus *Protopterus*, from which Dr Traquair concludes that there was probably a close connection between the present group and the Dipnoi. Other gigantic forms more and less closely allied to the type genus are *Titanichthys*, *Liognathus*, and *Diplognathus*, from the Devonian of Ohio; while *Typodus*, from the same formation in the Eifel, may perhaps belong to this family.

As Placodermata, of which the serial position is uncertain, may be mentioned *Menaspis*, from the Permian of Germany; *Acanthaspis*, *Acantholepis*, and *Aspidichthys*, from the Devonian of Ohio; *Pnigeacanthus* and *Lecracanthus*, from the Carboniferous of Iowa; *Stichacanthus* and *Phoderacanthus*, from the corresponding formation of Ireland and Belgium; and *Anomalichthys*, from the Devonian of Germany.

SUBORDER 3. ACANTHODEA.—The last group of the Proganoids is also Palæozoic, and ranges from the Devonian to the Permian, although it is not improbable that some of the genera, founded upon fin-spines, which are noticed under the Elasmobranchei, should be placed in it. The Acanthodeans appear to be in some respects intermediate between the Ganoids and Elasmobranchs, and should perhaps constitute an order by themselves. They have the body, which is more or less elongated and compressed, covered with shagreen-like scales, and with the lateral line running between two rows of such scales. The tail is heterocercal; and the fins have strong spines, which, except in the pectorals, are merely inserted between the muscles. There is considerable doubt as to the presence of cranial bones or of a gill-cover; but there is a ring of bones round the orbit. The vertebral column is cartilaginous, and teeth are either wanting or are very minute and sharp.

In their cartilaginous skeleton, the not improbable absence of an operculum, the structure of the scales and position of the lateral line, as well as in the spines of the median fins, the Acanthodei approach the Elasmobranchei; but the articulation of the pectoral fin-spine to the pectoral girdle is a character of the Teleostean *Siluridæ*, while the orbital ring is a character of the higher Ganoids like the *Palæoniscidæ*.

FAMILY ACANTHODIDÆ.—All the genera may be provisionally

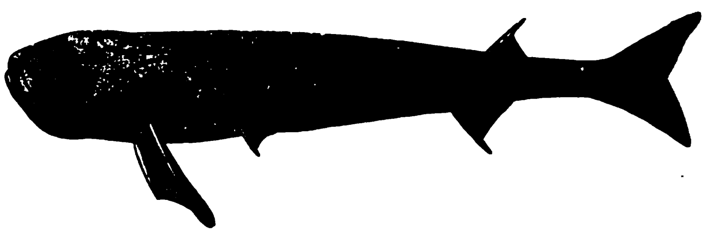


Fig. 898.—*Acanthodes*; from the Permian of Europe. (After Kner and Roemer.)

included in a single family, of which the type genus *Acanthodes* (fig. 898), as now restricted, ranges from the Carboniferous to the Permian of Britain and the Continent. The head is very short and blunt, and there is but a single dorsal fin placed immediately above the anal, while it is thought that teeth were absent. *Mesacanthus*, of the Scottish Devonian, includes small fishes distinguished from the last genus by the presence of an intermediate pair of small spines between the pectoral and pelvic fins; it is represented in the Devonian of Canada. Closely allied is *Acanthodopsis*, from the Carboniferous of Northumberland, in which there were numerous minute teeth; while *Chiracanthus* (fig. 899, 1), of the Scottish Devonian, is distinguished by the dorsal fin being placed in advance of the anal. In *Diplacanthus* (fig. 900) there are two dorsal fins, of which the second is placed above the anal; each pectoral fin has two spines; while there are minute spines between the pectoral and pelvic fins, and the jaws are furnished with small conical teeth. This genus is represented by several species in the Devonian of Scotland, and not improbably also occurs in that of Canada. *Rhadinacanthus*, from the Scottish Carboniferous,

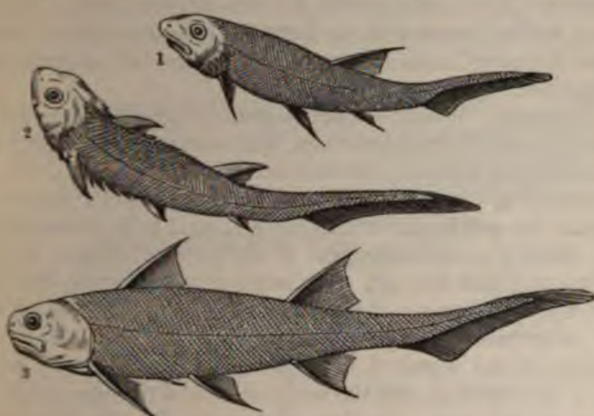


Fig. 899.—1, *Chiracanthus Murchisoni*; 2, *Climatius scutiger*; 3, *Ischnacanthus gracilis*; from the Devonian of Scotland. Reduced.

has two in place of four pectoral spines; while in *Ischnacanthus* (fig. 899, 3), of the same deposits, the small intermediate spines are wanting, although they are introduced in the figure. Allied to the last are *Euthacanthus* and *Parexus*, from the Scottish Devonian, the former having the second dorsal in advance of the anal

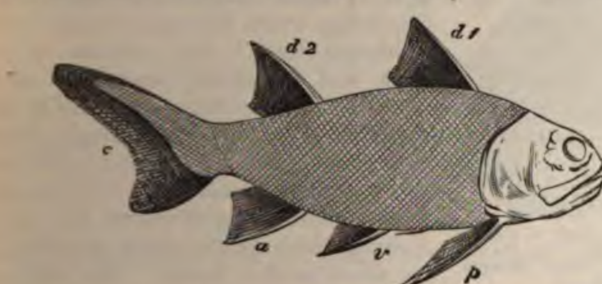


Fig. 900.—*Diplacanthus striatus*; from the Devonian of Scotland. *p*, Pectoral; *v*, Pelvic; *a*, Anal; *c*, Caudal; d^1, d^2, First and second dorsal fins. Reduced.

fin. Finally, the genus *Climatius* (fig. 899, 2) includes three small fishes from the last-named formation characterised by the short fin-spines and the presence of a series of accessory spines between the pectoral and pelvic fins. There are two dorsal fins, of which the second is behind the anal, the figure being incorrect in the respect. Fin-spines from the Devonian of Canada, describ *Ctenacanthus* and *Homacanthus*, are referred by Mr Woodwa *Climatius*.

INCERTÆ SEDIS.—Here may be noticed the family *Tarra* proposed by Dr Traquair for the imperfectly known genus *Tarr* from the Scottish Carboniferous, which is regarded as indicati aberrant type.

B. EUGANOID SERIES.—The remaining members of the include its typical representatives, and may be collectively l as the Euganoid series or the Ganoidei Veri.

SUBORDER 4. CROSSOPTERYGEA.—In this group the pectora sometimes the pelvic, fins consist of a central lobe surrounde fringe; there is an infraclavicular in the pectoral girdle; the r the dorsal and anal fins are often more numerous than the su ing interspinous bones; the preopercular extends forwards c cheek; branchiostegal rays are replaced by jugular plates; tl velopment of the vertebral column varies; the tail may be diphy- or heterocercal, and the scales cycloidal or rhomboidal. suborder is the most primitive of the true Ganoids, among it holds a position somewhat analogous to that occupied l Ichthyotomi in the Elasmobranchei.

FAMILY HOLOPTYCHIIDÆ.—In the type family the pector are acutely, and the pelvic subacutely, lobate; the skeleton former, according to Dr Traquair, being a biserial archipter like that of *Ceratodus*. The teeth are of the so-called *dend* type, the dentine of the base being in in an extremely complex manner, with branchings which form an intricate n within the crown. The scales are cyc thick, and sculptured; and there a dorsal fins, and a heterocercal tail in the inferior rays are much longer th superior. Before noticing the typical we may briefly mention the genus *Onyc* from the Devonian of North Americ Europe, which Dr Newberry conside be allied to this family. The scale 901) have distinct ridges, and the ma has a presymphysial production furnished with teeth arranged what like an old-fashioned cavalry spur. The type genus *ptychius* (fig. 902) comprises fishes, which are often of larg from the Devonian of Europe and North America. The two fins are placed in the hinder part of the body directly over tl vic and anal. We may probably place here the imperfectly l

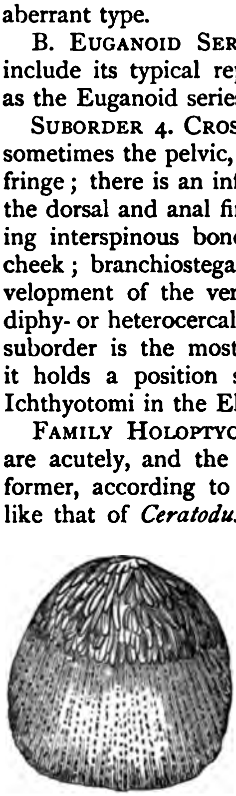


Fig. 901.—Scale of *Onychodus sigmoides*; from the Devonian of North America. (After Newberry.)

Platygnathus, from the Devonian of Scotland and Russia; *Isodus*, of the Irish Carboniferous; and *Peplorhina*, from the Trias of Illinois. In *Glyptolepis* (fig. 903), from the European and Canadian Devonian, we have a well-known form in which the dorsal fins are placed more anteriorly than in *Holoptychius*, while the anal is situated below the first dorsal, and the pelvic are consequently much

Fig. 902.—*Holoptychius nobilissimus*; from the Devonian of Scotland. A, A scale less reduced. The dorsal and anal fins should be more pointed.

more approximated to the pectoral fins. *Phyllolepis*, founded on very thick scales, which are sometimes smooth, from the Devonian and Carboniferous of Scotland, should probably be included in this family, in which Dr Traquair also places the imperfectly known genus *Dendrodus*, of the Devonian of Russia and Scotland. The jaws of the latter carry a small row of marginal teeth of conical form; while in the mandible there is a second row of much larger fang-like teeth, each of which has a distinct socket. These teeth

Fig. 903.—Restoration of *Glyptolepis*; from the Devonian of Scotland. Reduced. (After Huxley.)

are somewhat compressed, with trenchant fore-and-aft edges, and have the internal structure already noticed. *Colonodus*, of the British Carboniferous, and *Sigmodus*, of the Upper Palæozoic of northern India, should perhaps find a place in this family.

FAMILY RHIZODONTIDÆ.—In the Rhizodonts the pectoral fins are subacutely or obtusely lobate, the pelvic pair being usually non-lobate; while their internal skeleton forms a shortened uni archipterygium. The teeth are labyrinthodont in structure, la the complex internal network found in the preceding family. scales are cycloidal and sculptured; the median fins are numer the same as in *Holoptychius;* but the tail ap mates to the truly diphycercal type. The jaw has an inner series of tusk-like teeth 905). As an imperfectly known form we first mention *Cricodus* (*Polyplocodus*) from European Devonian. In the well-known *T chopterus*, of the Scottish Devonian, the bo much elongated, the tail distinctly heteroc the posterior fins are placed near the tai opercular bones are unusually large, and scales thin and striated. An apparently form is *Eusthenopteron* of the Devonian of ada, in which the vertebral centra appear to been unossified, while there are slight differ in the interspinous bones, tail, and teeth. cording to the views of Dr Traquair, *Gyropt* (fig. 904), from the Devonian of Scotlar allied to *Tristichopterus*, having scales o same general type (although some of these formerly thought to be rhomboidal), but a rhomboidal tail, and the exposed portion c scales relatively larger. From the Carbo ous of both Europe and North America we the type genus *Rhizodus* (*Megalichthys* in of which the typical species attained a very size. The larger teeth (fig. 905), on the evi of which the genus was originally founded the upper half of the crown smooth, whi lower half is longitudinally fluted. The te large individuals (which may attain a len nine feet) are nearly two inches in height *Rhizodopsis*, of the same deposits, the c bones form a well-developed shield on the rior surface resembling that of the *Osteolep* although the mandible agrees in general str with that of *Rhizodus*, and consists of art angular, and dentary elements; the latter a series of *infra-dentary* pieces on its inne which carry the large tusk-like teeth. The inferior space betwe mandibular rami is occupied by a series of jugular plates, of there is a large median pair, together with a small unpaired a

Fig. 904.—*Gyroptychius angustus*; from the Devonian of Scotland. Reduced. (After Pander.)

one, and a row of small lateral ones on either side. In the cranium the most striking feature is the anterior position of the orbit, which has three large suborbital bones behind it. Other more imperfectly

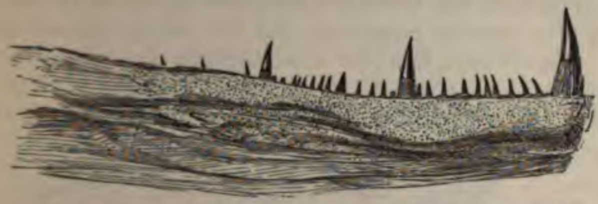


Fig. 905.—A mandibular ramus of *Rhizodus Heberti*; from the Carboniferous of Scotland. Reduced.

known genera of this family from the European Carboniferous are *Dendroptychius*, *Strepsodus*, *Rhomboptychius*, and *Archichthys*.

FAMILY OSTEOLEPIDIDÆ (RHOMBODIPTERIDÆ).—In this family the fins have the same general structure as in the preceding; but the scales are of the rhomboidal form typical of the order. There are a number of lateral jugular plates; the teeth are numerous and sharply-pointed; and the ossification of the vertebral column is

Fig. 906.—A, *Polypterus bichir*; from the Upper Nile. B, *Osteolepis macrolepidotus*; from the Devonian of Russia. (After Pander.) Both figures reduced. *a*, Pectoral; *b*, Pelvic; *c*, Anal; *d*, *d'*, Dorsal fins. In the lower figure the dorsal fins should be placed more in advance of the pelvic and anal.

imperfect. The family is divided into two subfamilies; the first, *Osteolepidinæ* (*Saurodipterini*) being characterised by the smooth scales, and presence of a median jugular plate. The type genus *Osteolepis* (fig. 906, B) has a long and slender body, with the two dorsals placed respectively in advance of the pelvic and anal fins. The type species is of considerable size. In the allied *Thursius*, of which an immature individual is shown in fig. 907, the dorsals are placed immediately over the pelvic and anal fins. Both genera occur in the Devonian of Scotland and Russia. Closely allied is the genus *Diplopterus*, from the Scottish Carboniferous, in which the dorsal fins are also situated posteriorly, the first being directly over the pelvic. *Megalichthys*, from the same deposits, comprises two species of large size; and is characterised by the presence of large fulcra at the roots of the pectoral, pelvic, and anal fins; and also by the

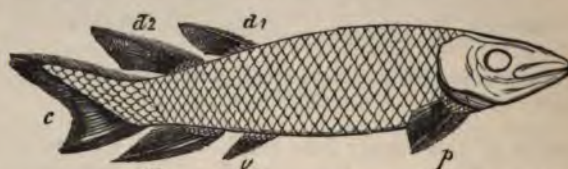


Fig. 907.—A young individual of *Thursius macrolepidotus*; from the Devonian of Scotland. Letters as in fig. 900. Reduced. (After Sedgwick and Murchison.)

small size of the anterior dorsal fin, which is placed above the pelvic fin. *Ectosteorhachis*, from the Permian of North America, is nearly related, and appears to be the last survivor of the family. The second subfamily, or *Glyptolæminæ*, is represented only by the genera *Glyptolæmus* (fig. 908) and *Glyptopomus*, of the Scottish Devonian; and differs from the last by the sculptured scales, and the absence of a middle jugular plate. The body is much elongated; there is a long interval between the pectoral and the posterior

Fig. 908.—*Glyptolæmus Kinnairdi*; from the Devonian of Scotland. Reduced. A, Scales. (After Huxley.)

fins; and the tail is truly diphycercal; each genus is represented by a single species.

Family Cœlacanthidæ.—With this family we come upon a group of fishes not occurring in the older Palæozoic, but extending from the Carboniferous to the Upper Cretaceous, and thus affording a link between the preceding extinct and the following existing family. The vertebral column is unossified; there are two dorsal fins, each of which is supported by a single forked interspinous bone; the pectoral fins are obtusely lobate; the caudal fin is unusually large, and completely diphycercal; the swim-bladder is ossified, and the scales are cycloidal. The members of this family are further characterised by the full development of the cranial bones; and the arrangement of the ossifications in the orbit ap-

Fig. 909.—Skeleton of *Undina penicillata*; from the Kimeridgian of Bavaria, one-fourth natural size. *a*, Jugular plates; *b*, Swim-bladder; *c*, Pelvis.

aches that found in the Labyrinthodontia. The type genus *lacanthus* ranges from the Carboniferous of Europe and North nerica to the Upper Trias of the former area, and is well charac-ised by the great thickness of its scales.

More or less nearly allied are *Diplurus* from the Trias of New

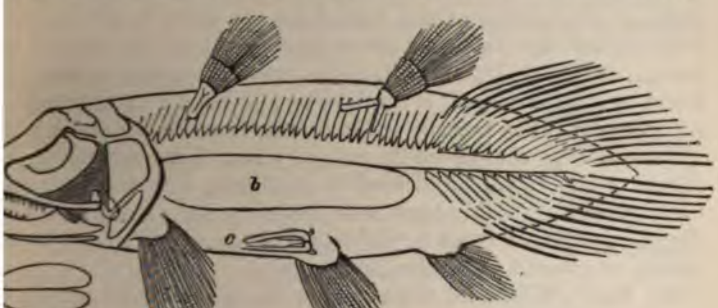


Fig. 910.—Skeleton of *Macropoma Mantelli*; from the Chalk of Sussex. Reduced. Letters as in fig. 909. (After Huxley.)

sey, *Graphiurus* from the Upper Trias of Carniola, and *Hepta-a* ranging from the Middle Trias to the Upper Jurassic of the ntinent. In *Undina* (fig. 909) the exposed parts of the scales marked by ridges, rising in some parts into spines, and the rays of the dorsal and caudal fins are divided and furnished with spines. In the English Liassic *Holophagus* the spines on the scales are more numerous, while in *Libys*, from the Kimeridgian of Bavaria, they are less numerous, the division of the fin-rays extends more deeply than in *Undina*, and the dorsal and caudal scales have a row of tubercles. *Coccoderma*, from the Kimeridgian of Europe, is allied to the last. Finally, *Macropoma* (fig. 910), from the Chalk, comprises several large species readily characterised by the notochord not extending to the extremity of the tail.

FAMILY POLYPTERIDÆ.—The last family of the suborder is known only by the existing African genera *Polypterus* (fig. 906, A) and *Calamoichthys*, each of which is represented by a single species. The vertebral column is ossified; the dorsal fin broken up into a number of small finlets; the pectorals are obtusely lobate; the caudal fin is diphycercal, with a very short body-axis; and the scales are rhomboidal.

SUBORDER 5. ACIPENSEROIDEA.—According to the views of Dr Traquair, the Acipenseroids, represented typically by the Sturgeons and their allies, and forming the Chondrostei of many authors, are also taken to include the Heterocerci, as represented by the extinct *Palæoniscidæ*. The following are some of the leading features of the group as thus defined. The paired fins are non-lobate; the pectoral girdle, which in the typical forms retains its primitive endoskeletal cartilages, develops dermal bones, among which the infraclavicular (fig. 913) is characteristic; the dermal rays of the dorsal and anal fins are more numerous than their supporting cartilages, or interspinals, of the endoskeleton; while in the paired fins these dermal rays have to a great extent replaced the original cartilages. In the skull the cartilaginous cranium persists in the typical forms, but in all cases it is overlain by a series of dermal bones; the preopercular, when present, tends to extend on to the cheek; branchiostegal rays are generally present; but there are never large jugular plates. The notochord is persistent, but there are either cartilaginous or bony neural and hæmal arches; the tail is heterocercal, and the skin may be either naked, or dotted over with bony scutes, or covered with rhomboidal scales.

Mr Smith Woodward remarks that the typical forms of this suborder constitute a link connecting the cartilaginous Ganoids with these fishes in which the bones are fully developed, and that their paired fins are more specialised than the median ones, which have not yet attained a numerical equality between the fin-rays and their supporting interspinals.

FAMILY ACIPENSERIDÆ.—The well-known Sturgeons (fig. 911), which form the typical family, are large fresh-water fishes, characterised by their elongated body, produced snout, toothless jaws of the adult, the presence of five rows of scutes formed of true bone on the body, and the sculptured cranial bones. The representatives of the existing genera *Acipenser* (fig. 911) and *Scaphirhynchus* are found in many of the larger rivers of the Northern Hemisphere. Scutes referred to *Acipenser* occur in the London Clay, and in some higher Tertiary beds; while spines from the English Upper Eocene

Fig. 911.—The Sturgeon (*Acipenser sturio*). Much reduced.

and the Pliocene of Montpellier probably also belong to the same genus. A single scute has also been described from the Miocene of Virginia under the same name.

FAMILY POLYODONTIDÆ.—In this family, now represented by *Polyodon* of the Mississippi and *Psephurus* of two rivers in China, the skin is typically nearly or quite naked, the mouth is of enormous width, and the jaws carry minute teeth. In a fossil state this family is represented by *Crossopholis*, from the Eocene of Wyoming, which displays many points of resemblance to *Polyodon*, but is remarkable for the possession of small pectinated scales, which are not confined to the upper lobe of the tail. The cranial bones are of the type of those of *Polyodon*, but the shorter rostrum indicates a resemblance to *Psephurus*. The scales are numerous, and are arranged in oblique rows, which are not quite in contact with one another. The retention of the scales in this genus indicates that we have to do with a much less specialised member of the family than the existing forms. The genus *Macropetalichthys*, from the Devonian of both North America and the Eifel, has frequently been referred to the *Polyodontidæ*, but without any sufficient evidence, and its serial position must for the present remain undetermined. The cranium (fig. 912) is short and broad, with the orbits completely surrounded by bone, and the middle line occupied anteriorly by a diamond-shaped ethmoidal shield, which articulates posteriorly with a process from the squared hinder shield.

Fig. 912.—Diagram of the frontal aspect of the cranium of *Macropetalichthys Sullivani*; from the Devonian of North America. Much reduced. (After Newberry.)

As an Acipenseroid of uncertain position may also be mentio[illegible] the imperfectly known *Pholidurus*, of the English Chalk—the [illegible] of which presents some resemblance to that of *Psephurus*. A [illegible] fish from the English Upper Lias, named *Gyrosteus*, is evide[illegible] also an Acipenseroid agreeing with the type genus in the absen[illegible] of teeth, but having a naked body. It differs also considerab[illegible] from the type of the next family, and its position must remai[illegible] uncertain.

FAMILY CHONDROSTEIDÆ.—This family is formed for the recep-tion of the one comparatively small fish constituting the genus *Chondrosteus* from the English Lower Lias. According to Dr Traquair, although there is no evidence of a long snout (fig. 913), this genus resembled *Polyodon* in the general form of the fins, and of the nearly naked body; but in other respects—such as the form of the cranial bones and the absence of teeth—approaches *Acipenser*. Certain features also appear to indicate distinct affinity with the

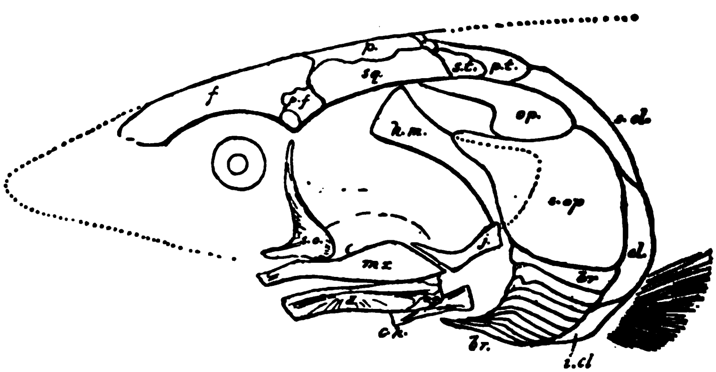
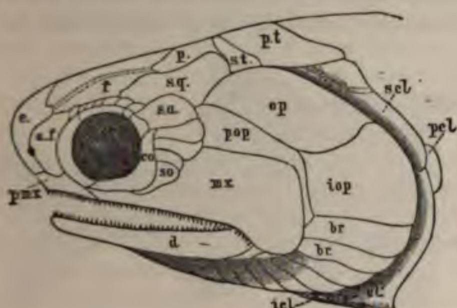


Fig. 913.—Profile view of the head of *Chondrosteus acipenseroides*; from the Lower Lias of Dorsetshire. Reduced. *f*, Frontal; *p.f*, Postfrontal; *p*, Parietal; *sq*, Squamosal; *s.t*, One of the supratemporals; *p.t*, Posttemporal; *s.cl*, Supraclavicular; *cl*, Clavicular; *i.cl*, Infraclavicular; *op*, Opercular; *s.op*, Subopercular; *br*, Branchiostegals; *c.h*, Ceratohyal; *ag*, Angular; *d*, Dentary; *mx*, Maxilla; *j*, Jugal; *h.m*, Hyomandibular; *s.o*, Suborbital. (After Traquair.)

Palæoniscidæ; and since the latter are evidently allied to the higher bony Ganoids, Mr Woodward suggests that they or allied forms may have given origin to two series, one of which culminated in the Teleosteans, while in the other "the only advance has been in the matter of size, and this accompanied by a certain amount of degeneration, culminating in Acipenseroids proper."

FAMILY PALÆONISCIDÆ.—This and the next family constitute the suborder Heterocerci of some writers. In the present family the body is fusiform, and covered with rhomboidal scales; the vertebral arches are ossified, but there are no bony ribs; the dorsal fin is single and short; all the fins have large fulcra at their bases; the ial bones are covered with ganoine, and mostly sculptured; the th is large; the first branchiostegal rays form jugular plates; e is a row of median V-shaped scales on the superior surface of extremity of the body; and the teeth are small, conical, or cylin-



g. 914.—Left lateral view of the skull of *Palæoniscus macropomus*; from the Permian. *p*, etal; *f*, Frontal; *sq*, Squamosal; *s.t*, Supratemporal; *p.t*, Posttemporal; *e*, Ethmoid; *a.f*, rontal; *pmx*, Premaxilla; *mx*, Maxilla; *co*, *sa*, *so*, Suborbitals; *d*, Dentary; *op*, Oper- r; *p.op*, Preopercular; *iop*, Subopercular; *br*, Branchiostegals; *cl*, Clavicular; *scl*, Supra- cular; *pcl*, Postclavicular; *icl*, Infraclavicular; *or*, Orbit. (After Traquair.)

al, and rarely plicate at the base. The chief characters of the es of the skull and of the secondary pectoral girdle are shown in 914, in which it will be seen that the preopercular covers a por- of the face above the large and broad maxilla. Dr Traquair rves that if a Palæoniscid were stripped of its scales and fur- ed with a long snout, it would be so like *Polyodon* that there ld be no doubt as to their near relationship; and he further rks that the one row of V-shaped scales found on the dorsal of the extremity of the body in *Polyodon* is identical with the of scales occupying the same position in *Palæoniscus*. This s to the conclusion that the existing Sturgeons are the survivors series of Ganoids, now totally lost, which formerly gave off the *eoniscidæ* and *Platysomidæ* as specialised branches.

his family embraces such a large number of genera, that space its of but little more than their bare enumeration. In the onian *Chirolepis*, found both in Europe and Canada, the body ender, and the fins are large, with the rays very finely divided; *Rhabdolepis* (fig. 915) of the Rothliegendes (Lower Permian), e having fins of somewhat similar structure, is distinguished by deeper and more spindle-shaped body. *Cosmoptychius*, of the ch Carboniferous, is allied to *Rhabdolepis*, but has the anal fin a longer base. In the type genus *Palæoniscus* (figs. 914, 916) body is much elongated, and the fins are very small and widely rated. It occurs in the Kupfer-Schiefer and Magnesian Limestone (Middle Permian) of Germany and England; and one species has been said to occur in the English Trias. That species is, however, now referred to the *Dapediidæ;* but a true *Palæoniscus* is recorded from the Hawkesbury beds of New South Wales, which may be of Triassic age. The remaining better known genera are *Elonichthys*, from the Carboniferous of Europe and America; *Acro-*

Fig. 915.—*Rhabdolepis macroptera;* from the Lower Permian of Saxony. Reduced. (After Agassiz.)

lepis, ranging from the Permian to the Carboniferous, and perhaps to the Devonian, of Europe; *Nematoptychius*, *Cycloptychius*, *Micronodus*, and *Gonatodus*, from the British Carboniferous; the gigantic *Amblypterus*, of the German Permian; *Rhadinichthys*, from the Carboniferous of both Europe and North America; *Eurylepis*, from the Carboniferous of Ohio; *Holurus*, *Canobius*, and *Phanerosteon*, of the Scottish Carboniferous; *Pygopterus*, of the German Permian; *Myriolepis*, from the Hawkesbury of New South Wales; *Urosthenes*, from the underlying Newcastle group of the latter country; *Gyro-*

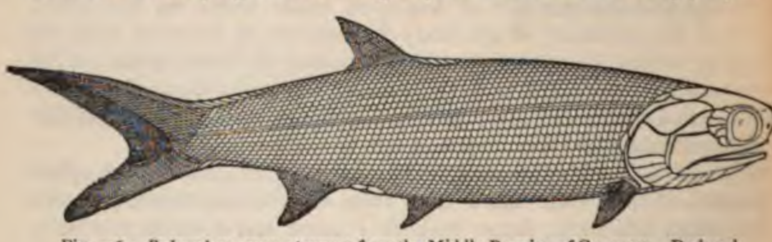


Fig. 916.—*Palæoniscus macropomus;* from the Middle Permian of Germany. Reduced. (After Traquair.)

lepis, from the Middle Trias of the Continent; and *Oxygnathus*, *Cosmolepis*, *Thrissolepis*, *Centrolepis*, and *Lissolepis*, from the English Lias. Here also may be mentioned the genera *Sphærolepis*, of the Permian of Bohemia, and *Coccolepis*, of the Kimeridgian of Bavaria, which, although having cycloidal imbricating scales, appear to be allied to the present family.

FAMILY PLATYSOMIDÆ.—The *Platysomidæ* agree with the preceding family in the characters of the vertebral column, fins, scales, and the main cranial structure, but differ by the body becoming deep and short, with an ovoid or rhomboidal contour, and also by minor modifications in the cranial structure. The teeth are small, and may be either sharp or obtuse. The chief difference in the structure of the skull consists in the deflection of its axis below that of the vertebral column, instead of being continuous; while the hyomandibular, instead of being very oblique, becomes nearly vertical, and the ethmoid is elongated. These changes cause the mouth to be separated widely from the orbit, the jaws to become "prognathous," and the gape of the mouth itself to be much reduced; they are readily apparent by contrasting the figure of *Palæoniscus* with that of *Chirodus*. Dr Traquair regards this family as a group of specialised forms descended from the *Palæoniscidæ*; their external resemblance to the *Dapediidæ* being probably due merely to adaptation to similar conditions of life, and not indicating a real affinity. In *Eurynotus* (fig. 917) the contour of the body is not so greatly

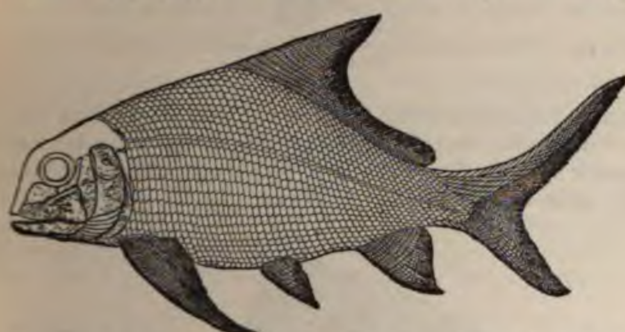


Fig. 917.—*Eurynotus crenatus*; from the Carboniferous of Scotland. Reduced. (After Traquair.)

removed from the Palæoniscid type; the pectoral fin is large, the dorsal also large, and beginning above the pelvic, while the base of the anal is short. This genus occurs in the Carboniferous of Scotland and Belgium. In *Benedenius*, of the Belgian Carboniferous, the body becomes more oval, and the dorsal fin is placed more posteriorly. More or less nearly allied to this group are *Mesolepis*, of the British Carboniferous; *Eurysomus*, of the Middle Permian of England and Belgium; and *Wardichthys*, of the Scottish Carboniferous. In *Chirodus* (fig. 918), of the British Carboniferous, the body is rhomboidal; the dorsal and anal fins have a long base, short rays, and an anterior spine; while the pelvic fin is unknown, and the pectoral small. Closely allied, again, is *Chirodopsis*, from the same horizon. The last and type genus *Platysomus* (figs. 91 and 920) is represented by a large number of species, ranging fro the Carboniferous of England and North America to the Midd

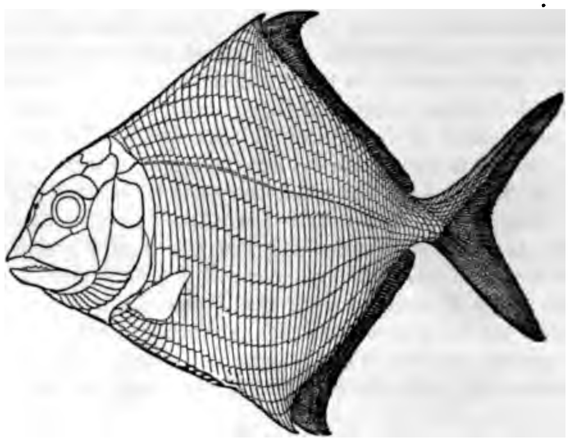


Fig. 918.—*Chirodus granulosus*; from the Carboniferous of Scotland. Reduced. (After Traquair.)

Permian of England and the Continent. The contour of the bo is less rhomboidal than in *Chirodus*; the dorsal and anal fins ha no anterior spines; the pelvic fin is very small, and but seldom pr served; while the pectoral is of medium size.

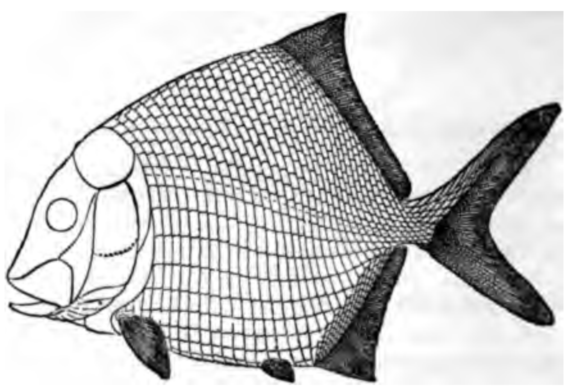


Fig. 919.—*Platysomus striatus*; from the Middle Permian of England. Reduced. (After Traquair.)

SUBORDER 6. LEPIDOSTEOIDEA.—In the Lepidosteoids the pai fins are non-lobate; there is no infraclavicular bone; the rays the dorsal and anal fins correspond in number with their supporting interspinous bones; the opercular bones are like those of the Teleostei; there is frequently a median jugular plate on the first pair of branchiostegals; the development of the vertebral column varies; the tail is of the masked heterocercal type; and the scales are rhomboidal, or may be occasionally replaced by angular scutes. This

Fig. 920.—*Platysomus gibbosus*; from the Middle Permian of Germany. Reduced. The pelvic fin is not shown.

suborder is represented at the present day by the somewhat aberrant *Lepidosteidæ*, and also by a large number of Mesozoic forms ranging from the Trias upwards. As already mentioned, the external resemblance of the *Dapediidæ* and *Pycnodontidæ* to the *Platysomidæ* is not regarded by Dr Traquair as indicative of real affinity.

FAMILY DAPEDIIDÆ.—In this family, which by some writers is subdivided and known as the *Sauridæ* and *Stylodontidæ*, the body is either fusiform or ovate; the opercular bones present certain

Fig 921.—*Semionotus Kapffi*; from the Keuper of Würtemberg. (After Fraas.)

characteristic features; the upper lobe of the body-axis of the tail, and usually the anterior borders of the other fins, have well-developed fulcra; the vomer and jaws carry several rows of small teeth, of which the outermost are curved and resemble claws (*griffelzahne*); and the ossification of the vertebral column is imperfect. Among the genera with fusiform bodies, one of the best known is *Semionotus* (fig. 921), which is widely spread over Europe. . According to Dr Deecke, this genus is represented in the Bunter and Muschelkalk; it is common in the Keuper, or Upper Trias, and thence ranges to the Kimeridgian, or Upper Jurassic. It has also been recorded from the Stormberg beds in the upper part of the Karoo system of South Africa; and it appears to be also represented in the Trias of North America, where it has received the name of *Ischypterus*. In these fishes the dorsal fin is small, the inequality of the scaled portion of the caudal strongly marked, and there is a row of large spine-like scales on the middle line of the back. Other more or less nearly allied forms, of which some were formerly included in *Palæoniscus*, are *Acentrophorus*, from the British Permian; *Catopterus*, from the North American Trias; and *Dictyopyge*, from the Trias of both England and North America, the type species of the latter having been originally named *Palæoniscus superstes*. In *Heterolepidotus*, typically from the Lower Lias of England, and *Heterostrophus*, from the Kimeridgian of Bavaria, we have genera in which the contour of the body is more like that of the type genus. *Heterolepidotus*, according to Dr Deecke, is also represented in the Muschelkalk, and survived to the Kimeridgian. The name *Allo-*

Fig. 922.—*Dapedius pholidotus*; from the Upper Lias of Würtemberg. Reduced.

lepidotus is applied to allied types also represented in the Muschelkalk. *Dapedius* (fig. 922), in which *Æchmodus* may be included, comprises a number of medium-sized fishes with broadly ovate bodies, ranging in Europe from the Keuper to the Lower Jurassic, but also occurring in the Kota beds of the Indian Gondwanas, which are somewhat higher than the Maleri beds from which *Ceratodus* is obtained. The dorsal and anal fins have elongated bases, and the inequality between the upper and lower lobes of the scaled part of the caudal fin is comparatively slight. In typical species the teeth are simple, while in others (on which *Æchmodus* was founded) they are forked at their summit; since, however, both types are occasionally found in a single species, they do not afford grounds for generic distinction. The so-called *Amblyurus* has been founded on crushed Liassic specimens of *Dapedius*. Allied forms are *Pleurolepis* and *Homœolepis*, from the Upper Lias of Würtemberg. In *Tetragonolepis*, of the European Lias and the Kota beds of the Indian Gondwanas, the body resembles that of the type genus, but the form of the dorsal and anal fins is different, the caudal fin is nearly symmetrical, and the vertebral centra develop rings of bone; all these characters approximating to the next family, in which Sir P. Egerton placed both this and the following genus. *Clithrolepis* is an allied genus typically from the Wianumattu and Hawkesbury beds of New South Wales, but also occurring in the Stormberg beds of the South African Karoo system, and not improbably in the Indian Kota beds; all these strata being of approximately equivalent age.

FAMILY PYCNODONTIDÆ.—The Pycnodonts form a compact group, ranging from the Lias to the Eocene, in regard to the serial

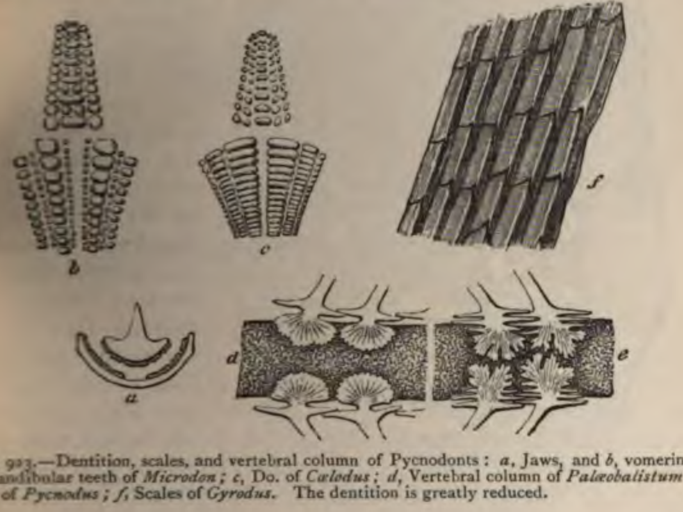


Fig. 923.—Dentition, scales, and vertebral column of Pycnodonts: *a*, Jaws, and *b*, vomerine and mandibular teeth of *Microdon*; *c*, Do. of *Cœlodus*; *d*, Vertebral column of *Palæobalistum*; *e*, Do. of *Pycnodus*; *f*, Scales of *Gyrodus*. The dentition is greatly reduced.

position of which very divergent views have been entertained. Dr Traquair is, however, disposed to regard them as specialised forms connected with the *Dapediidæ* and *Lepidotidæ*, and they are accordingly here placed between those families. This family has been recorded from Europe, Asia Minor, North America, and Australia, and presents the following characteristics. The body is of a rhomboidal shape, presenting a striking resemblance in this resp the *Platysomidæ ;* the caudal fin is of a completely masked h cercal type, and there are no fulcra to the fins. The notoch persistent, but the neural arches and ribs are ossified, and later forms the heads of the latter (fig. 923) are enlarged, so simulate portions of vertebral centra. The premaxillæ are too the conjoint palatines and vomer form a triangular bone (fig. carrying five longitudinal rows of oval or round molariform while in the mandible the dentary bones, which form the ext of the symphysis, have two or four chisel-like teeth, and the sp are enlarged and carry on either side from three to five or rows of molariform teeth (fig. 923) opposed to those of the f Commencing with the typical genus *Pycnodus*, we find this, a defined, restricted in Europe to the Lower Eocene of Sheppe the Middle Eocene of Monte Bolca in Italy. There are only rows of teeth on either side of the mandible, of which the inne is the largest ; wh the vomer the te the three inner ro round, and tho the two outer ro larger and oval. characters are fo the position o orbit, the large s the mouth, an superiority in the of the dorsal as pared with the an A fish from the ceous of Brazil ha referred by Pr Cope to this The allied *Palæ tum* (fig. 923, which all the teeth are sub occurs in the of the Lebano Cretaceous Pisol Mont Aimé in F and also in the Middle Eocene of Monte Bolca. The g number of the Cretaceous forms are, however, referable genus *Acrotemnus Cœlodus*,[1] which comprises some species att

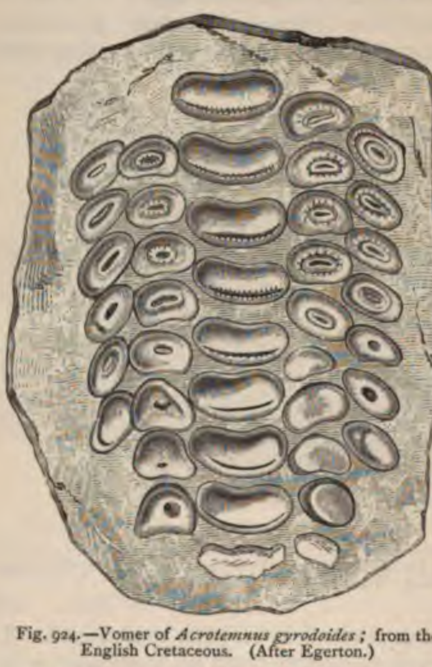


Fig. 924.—Vomer of *Acrotemnus gyrodoides ;* from the English Cretaceous. (After Egerton.)

[1] The name *Cœlodus* being preoccupied by *Cœlodon*, the term *Acrotemn* posed by Agassiz for detached teeth, is adopted.

a large size. The vomerine teeth (fig. 924) of the middle row are elliptical, and much larger than either of the others, while there are usually three rows on either side of the mandible, although these are occasionally increased to four. The dorsal fin extends in advance of the anal. This genus ranges from the Gault to the Chalk, and is widely spread through Europe. In *Mesodon* we have a genus ranging from the English Lias to the Lower Kimeridgian of Bavaria, and not improbably also represented in the Lower Greensand. Here the vomerine teeth of the middle row are larger than the teeth of the other rows, which are exceedingly small, and in the outermost line have a wart-like surface. Allied genera are *Mesturus* and *Athrodon* from the Kimeridgian of the Continent.

Stemmatodus (fig. 925), which comprises two small species from the Lower Cretaceous of Italy, is characterised by the great length

Fig. 925.—*Stemmatodus rhombus*; from the Lower Cretaceous of Italy.

of the dorsal and anal fins, and also by the concave surfaces of the molariform teeth, which are of subequal size. *Microdon* is another allied genus, ranging in Europe from the Kimeridge to the Purbeck. The arrangement of the teeth, and the peculiar structure of the heads of the ribs are shown in fig. 923. In *Gyrodus* we seem to have the most specialised members of the entire family, all of them being characterised by the sculptured crowns of the molariform teeth. The vomer is very narrow, and has the teeth subcircular, those of the middle row being much the largest; while in the mandible there are four rows on either side, of which the first and third are the larger. This genus is especially abundant in the Lower Kimeridgian lithographic limestone of Bavaria, but it also ranges upwards into the Chalk of Sussex, and downwards into the Lower Jurassic Stonesfield Slate. Finally, *Coccodus* is founded on an imperfect specimen from the Chalk of the Lebanon really belonging to this family, but which has been referred to the Teleostean Siluroids.

FAMILY LEPIDOTIDÆ (SPHÆRODONTIDÆ).—In the *Lepidotidæ* the body is more or less fusiform, the upper scaled portion of the tail is longer than the lower, and the fulcra of the fins are well developed. The palatine, vomer, maxilla, and dentary carry rows of knob-like teeth (fig. 926), while the premaxilla is furnished with teeth of a chisel-like form. The type genus *Lepidotus* (fig. 926), with which *Sphærodus* is in great part identical, has a wide distribution both in time and space. Thus, in Europe it ranges from the Muschelkalk, or Middle Trias (where its scales have been described under the names of *Dactylolepis* and *Thollodus*) to the Chalk, and it also occurs in the Kota group of India, and the Cretaceous of Brazil and of North America. The large button-like teeth of *L. maximus* are abundant in the Kimeridge Clay, and specimens have been

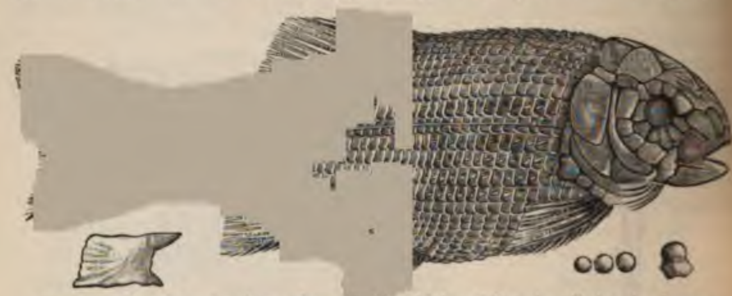


Fig. 926.—*Lepidotus maximus*; from the Kimeridgian of Bavaria. Reduced. Larger views of teeth and a scale are given in the corners.

found comprising nearly the whole palate, and exhibiting the curious manner in which the replacing teeth gradually turn over as they come into use. The names *Nephrotus*, *Cenerodus*, *Omphælodus*, *Hemilopus*, and *Asterodon*, have been applied to molariform and chisel-like teeth belonging to members of this family from the Trias of Silesia and Thuringia; while teeth of the latter type from the bone-bed of the same period, in both Würtemberg and England, described under the name of *Sargodon*, should, perhaps, be likewise placed here; and *Neorhombolepis*, of the English Chalk, appears to be an allied form.

FAMILY EUGNATHIDÆ (SAURODONTIDÆ).—The body in this family is long and slender; the snout short; the fins have fulcra, the caudal being of a partially or completely masked heterocercal type; the vertebral centra may be either imperfectly or fully ossified, and the teeth are pointed. The range in time of this family extends from the Upper Trias to the Neocomian of Europe, but may, perhaps, also include the Chalk. In the typical group we have *Eu-*

nathus ranging from the Keuper to the Kimeridgian, while in the Lias we find *Platysiagum* and *Ptycholepis*, and *Pholidopleurus* and *Peltopleurus* in the Keuper. A second group is represented by *Pleuropholis*, of the Kimeridgian of Bavaria, and also by *Thoracopterus* and *Pterygopterus* of the Keuper, the latter being distinguished by the absence of the pelvic fins. The genus *Pholidophorus* includes small Fishes somewhat resembling a Carp in form, which range from the Muschelkalk to the Purbeck. A fish from the Muschelkalk, originally described as *Pholidophorus porro*, has been made the type of the genus *Prohalecites*, on account of peculiar features in its squamation. Larger forms are ranked under the genera *Isopholis* of the Lias and Kimeridgian, and *Ophiopsis*, which extends from the Lias to the Purbeck. Of the remaining genera we have *Eusemius* and *Propterus* in the Kimeridgian of Bavaria; *Notagogus* from the latter deposits, and also in the Lower Greensand of Italy; *Histionotus* in the Bavarian Kimeridgian and the English Purbeck; *Macrosemius* ranging from the Stonesfield Slate to the Kimeridgian of Bavaria; and *Legnonotus* from the English Lias. *Lophiostomus*, from the Chalk of Sussex, may perhaps be placed here, although its skull approximates to that of *Amia*. The scales are pitted, and have a pectinated posterior border.

FAMILY ASPIDORHYNCHIDÆ (RHYNCHODONTIDÆ).—In this family the body is much elongated, and covered with scales of unequal

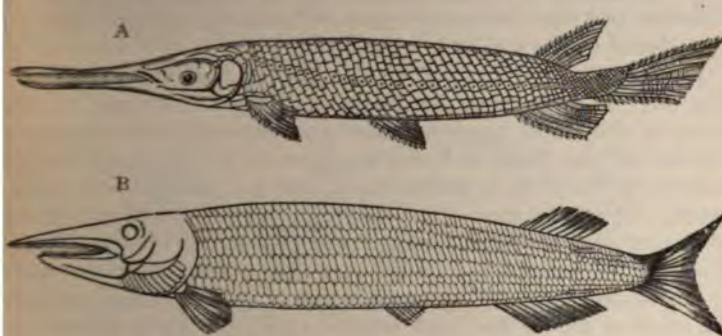


Fig. 927.—A, The Gar-pike (*Lepidosteus osseus*). Recent. North America. B, *Aspidorhynchus*; from the Jurassic. Both much reduced.

sizes; the skull is produced into a short rostrum; the caudal fin is of the masked heterocercal type; the fins carry fulcra; the vertebræ have ossified rings; and the teeth are either blunt or sharp. This family is represented only by the Mesozoic genera *Aspidorhynchus* and *Belonostomus*, in both of which the dorsal fin is placed above the anal. In the former (fig. 927, B), which ranges from the Lias to the Purbeck, the length of the upper jaw exceeds that of the lo and in advance of the mandibular symphysis there is a predent bone (not shown in the figure) apparently corresponding to the found in certain Dinosaurs. In *Belonostomus*, which, as now stricted, ranges from the Lower Kimeridgian of Bavaria to Chalk, the predentary bone is so much elongated as to make upper and lower jaws of nearly equal length, and the predent carries a median row of large conical teeth, flanked by two rows minute teeth; the teeth of the normal bones of the jaws havi mammilated crowns adapted for crushing.

FAMILY BELONORHYNCHIDÆ.—This family name has been p posed by Mr S. Woodward for the remarkable genus *Belonorhynch* typically occurring in the Upper Trias of Carinthia, but also fou in the Lower Lias of Dorsetshire, where the specimens had be originally referred to *Belonostomus*. According to the writer quot *Belonorhynchus* was allied to the latter genus, having a similar lo and slender body, with the same general position and structure the fins, and probably furnished with a predentary bone. The fulc of the fins were, however, either absent or very minute; and, wi the exception of a median dorsal and ventral series of scutes, a another series on the lateral line, the body was naked. The i perfectly known *Saurichthys*, from the Rhætic of Bristol, is a clos allied, if not generically identical, type. Specimens of the upp jaw show that (as in *Belonorhynchus*) the bone was covered with fi tubercles, and that the maxillæ gave off horizontal palatal plates, li those found in Amphibians and Reptiles.

FAMILY LEPIDOSTEIDÆ.—The Gar-pikes of the genus *Lepidost* (fig. 927, A), inhabiting the freshwaters of Northern and Cent America and Cuba, agree with the *Aspidorhynchidæ* in the gene contour of the body and the arrangement of the fins; but t rostrum of the skull is much longer, and the tail distinctly hete cercal. The scales are lozenge-shaped. The existing genus appe to be represented in the Lower Eocene of France by a species (*Maximiliani*) formerly referred to *Lepidotus*; and it may also oc in the Upper Eocene (Oligocene), where a species described un the name of *Naisia* has been referred to it. In North America have also *Pneumatosteus*, from the Miocene, and *Clastes*, from Lower Eocene, both being freshwater forms, and the latter a occurring in the Eocene of Rheims.

SUBORDER 7. AMIOIDEA.—According to Dr Traquair's clas cation, the last and most specialised suborder of the Ganoids typically represented by the existing *Amia* and a series of Mesoz genera approximating more or less closely to the Teleostei. these forms the paired fins are non-lobate; the infraclavicular bon absent; the operculars are Teleostean; the branchiostegals hav median jugular plate; the vertebræ are more or less completely ossified; the tail is masked heterocercal; and the scales are thin and usually cycloidal. In all cases the teeth are small and pointed. It is probable, indeed, that in the Mesozoic representatives of this group we have forms closely allied to the ancestors of the Teleostei, and it is more than likely that future discoveries will show a complete passage between the Ganoids, as represented by this suborder, and the Teleosteans.

FAMILY PACHYCORMIDÆ (MICROLEPIDOTI).—According to Professor Zittel, *Pachycormus* and its allies should be placed in this suborder, although other writers have regarded them as more nearly related to the *Dapediidæ*. In these forms the scales, although thin and imbricating, are subrhomboidal, and the vertebral column is very incompletely ossified. The chief genera, which are European, include *Pachycormus*, ranging from the Lias to the Oxford Clay (Middle Jurassic); *Endactis*, from the Lower Lias; *Euthynotus*, of the same horizon; and *Hypsicormus*, *Sauropsis*, and *Agassizia*, of the Lower Kimeridgian of Bavaria.

FAMILY CATURIDÆ.—The Caturoids are a family of Salmon-shaped fishes, varying greatly in size, and ranging in time from the Lias to the Chalk, but especially common in the Kimeridgian lithographic limestones. The vertebral column may be either very imperfectly or completely ossified, the tail is more or less deeply forked, and the fins have fulcra. *Caturus* itself comprises a number of species, some of which are of large size, and two of which are represented in figs. 928, 928 *bis*. The scales are very like those of the Teleosteans,

Fig. 928.—Skeleton of *Caturus furcatus*; from the Kimeridgian of Bavaria. Reduced. *p*, Pectoral; *v*, Pelvic; *a*, Anal; *c*, Caudal; *d*, Dorsal fin.

but still retain the Ganoid character of an inferior layer of bone and an upper one of enamel. The dorsal fin is placed immediately above the pelvic. This genus ranges from the Lias to the Kimeridgian, *C. maximus* attaining a length of three feet. *Strobilodus*, from the Kimeridgian of England and the Continent, is a closely allied if not identical genus. Other genera are *Isocolum*, from the Dorsetshire Lower Lias; and the Jurassic *Liodesmus*, *Eurycormus*, *Oligopleurus*, *Enoscopus* (*Attakeopsis*), *Macrorhipis*, and *Æthalion*. *Oligopleurus* has the dorsal fin placed behind the pelvic; and in this and of the other genera the vertebræ consist of the upper and horse-shoe-shaped elements mer in the preliminary notice of the

Fig. 928 *bis*. — Skeleton of *Caturus elongatus*; from the Kimeridgian of France. One-half natural size. (After Zittel.)

FAMILY LEPTOLEPIDIDÆ.—C ing similarity in external cont the Caturoids is the genus *Le* (fig. 929), which is placed Günther next to that family, al some palæontologists regard i Teleostean. The vertebral col fully ossified, and the fins are out fulcra. In this genus, ranges from the Lias to the idgian, the dorsal fin is plac mediately over the pelvic; *Thrissops*, of the Kimeridgian above the anal. In external ters these Fishes cannot be guished from Teleosteans; an probable that they are inti connected with that order, e they should not be placed in

FAMILY AMIIDÆ.—In the A the vertebral column is fully o and in the caudal region has a of centra bearing the neura hæmal arches, which alternat intercentra devoid of such a ages. Fulcra may or not be ent; and the caudal fin is c with the extremity of the ve column bent sharply up int upper lobe. In *Megalurus*, Purbeck and Kimeridgian, fulc present, and the dorsal fin is and does not extend in adva the pelvic. *Lophiurus*, fror same horizon, and *Opsigonus* and *Amiopsis*, of the Lower are other genera, of which the first two are nearly relat *Megalurus*. The existing *Amia*, of the freshwaters of the so United States, has no fulcra, and the dorsal fin occupies quarters of the length of the body. It appears probable th genus is represented in the Upper Eocene (Lower Oligocene the Lower Miocene of the Continent, where its remains have scribed under the names of *Cyclurus* and *Notæus*; and it also curs in the Eocene of Colorado and Wyoming, where it has been scribed as *Protamia* and *Hypamia*. The Eocenes of the latter trict and of Rheims have also yielded the allied *Pappichthys*,

Fig. 929.—*Leptolepis sprattiformis*; from the Kimeridgian of Bohemia. Letters as in fig. 928.

which there is but a single row of teeth; and members of this mily may occur in the Chalk of the Lebanon.

INCERTÆ SEDIS.—The remarkable genus *Dorypterus*, of the Perian of Hesse and Durham, may be conveniently noticed here, since s position is very problematical. In this remarkable fish the body shaped somewhat like that of a Sunfish, and the anterior part of e dorsal fin is taller than the whole depth of the body. There e, moreover, the Ganoid characters of fulcra to the fins, and the otochordal condition of the vertebral column; but, on the other and, there are no ganoid scales, and the pelvic fins are placed in dvance of the pectorals, as in some of the Teleostei. On account this curious combination of characters, Professor Cope has prosed to make *Dorypterus* the type of a special order, the Dorypteri, with the family *Dorypteridæ*.

CHAPTER L.

CLASS PISCES—continued.

ORDER TELEOSTEI.

ORDER VI. TELEOSTEI. — The last, and in many respect: most highly organised, order of Fishes is the Teleostei, whic cludes the greater number of existing forms, and (unless sor the genera here placed in the Amioidea belong to it) does no1 back beyond the Cretaceous. The Teleostei are in all proba descended from the Ganoids, and occupy in the class a som analogous position to that held by the Squamata among the Re and the Passeres among Birds; all traces of Amphibian affi having been entirely lost in this order.

It is impossible to give a definition of the order by which i be sharply separated from the Ganoids, but the following a most characteristi tures from a pa tological point of The body is u covered with thin tic, cycloid, or ct scales (figs. 832, but bony scutes o oid scales are occ ally present. The of the endoskelet well ossified; an gills are freely sus ed in a gill-cavity ed by a well-deve operculum (fig. The caudal fin c adult is of that completely masked heterocercal type usually te homocercal (fig. 931). The pelvic fins may be either abdo

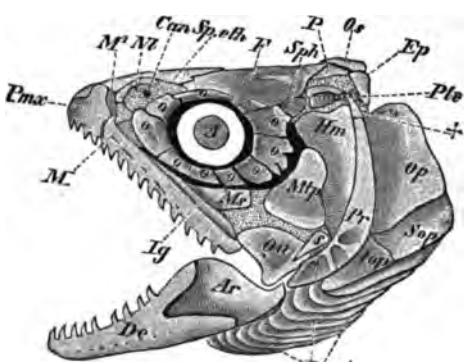


Fig. 930.—Skull of Trout (*Salmo*). Reduced. Letters as in fig. 843, p. 917.

laced in advance of the pectorals. The fin-rays may or may be articulated; and there are never fulcra on the fins. There two pairs of nasal openings on the top of the head. Other acters are found in the soft parts which are not usually avail- in the case of fossils.

t may further be observed that Teleosteans agree with Ganoids he hyostylic structure of the skull, and that cranial bones and a ndary pectoral girdle (fig. 844) are always developed. The ngement of the cranial bones in a typical Teleostean is shown g. 930, where it will be seen that the preopercular (*Pr*) does not

. 931.—Skeleton of the Perch (*Perca fluviatilis*). Reduced. Letters as in fig. 836, p. 913.

end on to the face as it does in some Ganoids. In certain forms, wever (*Siluridæ*), the cranium develops large bony plates, articu- ng with others in the cervico-dorsal region, and presenting a king resemblance to some of the cartilaginous Ganoids. In the ne group strong spines, articulating with the underlying bones, are eloped in the pectoral and dorsal fins; while the Salmonoids, many uroids, and others develop behind the rayed dorsal an additional without rays, to which the name *adipose* or *fatty fin* is applied.

According to Dr Günther's classification, the Teleostei are divided o six suborders, but other writers would group the last five of se together under the name of Physoclysti, as of equivalent value the first, or Physostomi. The former arrangement will be fol- ved here, but only such families as are of importance to the læontologist can be noticed.

SUBORDER I. PHYSOSTOMI.—In this suborder the swim-bladder, en present, is connected by a duct with the pharynx; the pelvic s are generally abdominal in position, and have no spine; while the fin-rays are articulated, but sometimes only the first rays of dorsal and pectoral fins are ossified. This suborder comprises the most generalised Teleosteans, and those most nearly connected with the bony Ganoids.

FAMILY SALMONIDÆ.—The members of this and the next family are so intimately connected by fossil forms, that it is very difficult to draw any distinction between them, and it has accordingly been proposed by some writers that they should be united under the name *Halecidæ*. The fossil genus *Halec* is, however, very imperfectly known, and if it be eventually found advisable to merge the two families, it would seem preferable to employ the name *Salmonidæ* in this wider sense. Existing Salmonoids are characterised by the presence of an adipose dorsal fin, and by the premaxilla and maxilla forming the borders of the mouth, and both bearing teeth. There are no scales on the head, and no barbels to the mouth. Recent Salmonoids are either marine, or inhabitants of the fresh-waters of the Northern Hemisphere. Remains of the existing marine genus *Osmerus* (Smelt) occur in the Upper Greensand of Germany, the Lower Eocene of Glarus, in Switzerland, and the Miocene of Licata, in Sicily; while nodules of unknown age found in Greenland and Canada enclose a species of *Mallotus* indistinguishable from the existing *M. villosus* of the former region. As forms connecting the Salmonoids with the Clupeoids we may notice *Aulolepis*, *Acrognathus*, and *Osmeroides*, from the English Chalk. The first has a rounded body and a depressed head, with minute teeth, and the pelvic fins abdominal. In the second the orbits are of enormous dimensions, and the teeth extremely minute. The third genus (fig. 932) is also abundantly represented in the Chalk of the Lebanon, and appears to have no adipose fin; its skeleton in many

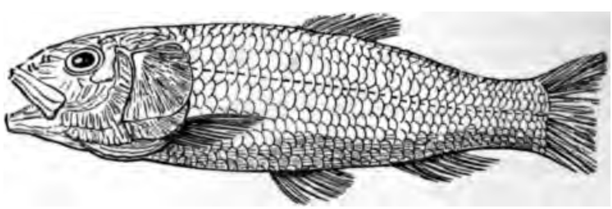


Fig. 932.—*Osmeroides lewesiensis*; from the Chalk of Sussex. Reduced.

respects resembles that of the Clupeoids, but the ribs have not the peculiar structure of that group. *Sardinius*, from the Chalk of the Lebanon, and *Sardinoides* from the same locality, and also from the Chalk of Westphalia, are more or less closely allied forms; while *Opisthopteryx*, of the Lebanon Chalk, may also be provisionally placed here.

FAMILY CLUPEIDÆ.—The existing members of the Clupeoid or Herring family differ from the Salmonoids by the absence of the adipose fin, and the presence of peculiar dermal ossifications at the ends of the ribs, which form bony plates on the sides of the thorax. All the numerous forms are marine, and usually occur near the coasts. The type genus *Clupea* (Herring) occurs in the Miocene of Würtemberg, the Upper Eocene of the Isle of Wight, the Eocene of Wyoming and Glarus, and the Chalk of the Lebanon. The

Fig. 933.—The Common Herring (*Clupea harengus*). Reduced.

common existing Herring is shown in fig. 933. The Lebanon Chalk has also yielded a species of the living genus *Engraulis*; and the extinct genera *Scombroclupea*, *Leptosomus*,[1] *Chirocentrites* (also in Westphalia), and *Spaniodon*, which are more or less closely allied to existing types. In the Eocene of the Continent we have representatives of the existing genera *Engraulis* (Anchovy) and *Chanos*, and the extinct *Platinx*, *Cœlogaster*, and *Crossognathus*—the latter being allied to the existing *Megalops*.

In this place we may conveniently notice a number of extinct genera more or less allied to the Clupeoids, but of which the family

Fig. 934.—Skeleton of *Rhinellus furcatus*; from the Cretaceous of the Lebanon. Reduced. (After Pictet and Humbert.)

position is in some instances uncertain, and some of which retain indications of marked affinities to the higher Ganoids. One of the most remarkable of these is *Rhinellus* (fig. 934), in which the skull

[1] Preoccupied by *Leptosoma*.

is produced into a rostrum, occasionally equal in length to the entire body; this genus occurs in the Chalk of the Lebanon, a is considered to show affinity with *Opisthopteryx*. Another gro seems to be related to the existing Clupeoid genus *Elops*, but al presents characters connecting it with the American freshwat family *Characinidæ*. Among these we may notice *Rhacolepis*, fro the Cretaceous of Brazil; and in Europe *Elopides*, from the Low Eocene of Glarus; *Elopopsis*, from the Cretaceous of Bohemia a Istria; *Hemielopopsis*, in which the borders of the mouth appear to have been devoid of teeth, from that of Lesina, on the Dalmatian coast; and *Protelopis*, of the Bohemian Cretaceous, characterised by the short jaws and the presence of crushing-teeth on the palate. *Thrissopater*, again, from the Folkestone Gault, differs from the modern Elopine type by its compressed body; while *Halec*, of the European Chalk, is still very imperfectly known. *Alosa*, of the

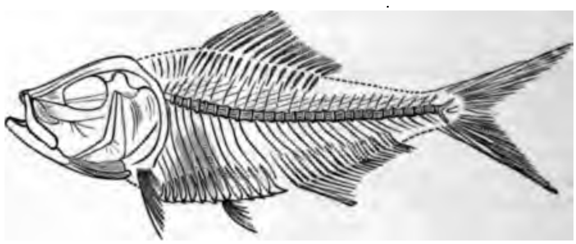


Fig. 935.—Skeleton of *Diplomystus brevissimus*; from the Chalk of the Lebanon.

Eocene of Algeria, and *Diplomystus* (fig. 935), originally described from the Eocene of Wyoming, but subsequently found in the Cretaceous of Brazil and of the Lebanon, are allied forms. The latter genus has a series of dorsal scutes, which are very characteristic. *Hemitrichias*, from the Tertiary of Northern Italy, differs from all existing Clupeoids in having two dorsal fins.

FAMILY PROTOSPHYRÆNIDÆ.—With this family we come to the first of a group comprising several families of extinct marine Fishes characterised by their large spear-like teeth, and hence termed Saurodonts. They should evidently be placed near the Clupeoids, although their division into families must be regarded as provisional. The present family is characterised by the production of the ethmoid in advance of the maxilla, to form a long cylindrical rostrum; by the loose connection of the premaxillæ with the maxillæ; and probably also by the complexity of the mandible. The teeth were implanted in distinct sockets. The type genus *Protosphyræna* (*Erisichthe*) occurs in the Upper Cretaceous of both Europe and North America; and the large spear-like teeth of *P. ferox*, which

: same distribution as the genus, are very common in the tic beds of the Cambridge Greensand, and were for a long ferred to the American *Saurocephalus lanciformis*, which was hought to be a Reptile. These teeth are compressed, and : marginal serrations. The fins were provided with large spines, which were at one time referred to the Selachian *Ptychodus*, and subsequently were made the type of another under the name of *Pelecopterus*.

ILY DERCETIDÆ (HOPLOPLEURIDÆ).—The members of the l family of Saurodonts are characterised by their elongated their powerful dentition, and the presence of several series ;e triangular scutes along the sides of the body; there is ie dorsal fin in those forms in which the fins are known; eth are not implanted in sockets; and the skull is frequently :ed into a rostrum. This family probably passes impercep-nto the next.

: typical genus *Dercetis* (in which *Leptotrachelus* may be in-l) occurs in the Chalk of England, Bohemia, and the Lebanon, so in the Upper Cretaceous of Westphalia; it is characterised length of the upper jaw exceeding that of the lower, and by esence of five rows of scutes, of which the middle one bears eral line. The allied *Aspidopleurus* is confined to the Lebanon Other members of this family are *Blochius*, from the Middle e of Monte Bolca; *Plinthophorus*, of the English Chalk; *rhynchus*, from the Upper Cretaceous of Westphalia; and *hamphus*, from that of Istria. *Plinthophorus* has two rows of but is otherwise naked.

ILY ENCHODONTIDÆ.—The genera which may be provision-ouped under this name are distinguished by the moderate compression of the body, which may be either naked or

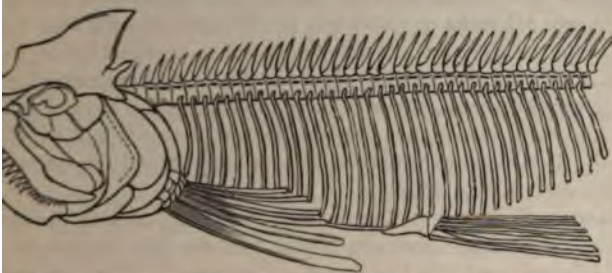
Fig. 936.—Skeleton of *Eurypholis Boissieri*; from the Chalk of the Lebanon. Reduced. (After Pictet and Humbert.)

d with scutes, and by the elongated premaxillæ and maxillæ, carry small teeth anchylosed (like those of the mandible) to ne. A considerable portion of the maxilla is excluded from argin of the jaw by the premaxilla; teeth occur on the palatines and ectopterygoids; and the dentary bone of the mandible has one series of large teeth, with one or more inner rows of small ones. The type genus *Enchodus*, with which *Eurygnathus* of the Lebanon beds is identical, occurs in the Upper Cretaceous of Europe, North America, Brazil, and perhaps India. Closely allied to this genus is *Eurypholis* (fig. 936), of the Lebanon Chalk, which is merely distinguished by the presence of a few dermal scutes. *Cimolichthys*, from the Upper Cretaceous of Europe and the United States, and *Pomognathus* (*Phylactocephalus*), from the Chalk of Europe and the Lebanon, are nearly related genera, mainly distinguished by their dentition. Here also may be placed *Ischyrocephalus*, of the Upper Cretaceous of Westphalia, which may perhaps have had two dorsal fins, and appears to connect *Enchodus* with the *Dercetidæ*.

FAMILY PACHYRHIZODONTIDÆ.—Allied to the preceding, but with the body more compressed, and covered with either scutes or scales, or both together, is a group of Fishes which may be provisionally placed in a distinct family. The premaxillæ and maxillæ are large, and carry powerful teeth, which may form one or more rows, and are set in incomplete sockets, and anchylosed to the bone; while the abdominal vertebræ are characterised by their longitudinal striation and the absence of deep pits. The type genus *Pachyrhizodus* (*Hypsodon* in part) ranges in Europe from the Chalk to the London Clay, and also occurs in the Cretaceous of North America; its teeth are so like those of Reptiles that a lower jaw was described as belonging to a species of *Mosasaurus*. *Empo*, of the North American Cretaceous, may be certainly placed in this family; in which we may also probably include *Stratodus*, of the Upper Cretaceous of both Europe and North America. An allied type, from the Lower Miocene of Belgium, has been described under the preoccupied name of *Amphodon*.

FAMILY SAUROCEPHALIDÆ (SAURODONTIDÆ).—The last family of the Saurodonts are laterally compressed Fishes, in which the maxillæ and premaxillæ are large, and carry powerful teeth, which are usually implanted in distinct sockets. The dentary bone of the mandible has but a single row of similar teeth, and there are no teeth on the palatines and ectopterygoids. The vertebræ, with the exception of those of the cervical region, carry two deep grooves and pits on their lateral surfaces. The type genus *Saurocephalus* is represented in the Cretaceous of North America, and also by a single species in the topmost Cretaceous of Maastricht, in Holland; the teeth are subequal and closely approximated. *Ichthyodectes* and *Portheus* (fig. 937) also occur in the Upper Cretaceous of both Europe and North America; the latter, which extends down to the Gault, attaining large dimensions, and being characterised by the great crest in

and English Cretaceous; the English species apparently
ng the typical American one with *Ichthyodectes*. *Saurodon*
from the Upper Greensand of New Jersey; while we may



—The anterior portion of the skeleton of *Portheus molossus*; from the Cretaceous of North America. Greatly reduced. (After Cope.)

nally place in this family the imperfectly known *Tomognathus*,
English Chalk, in which the teeth were anchylosed to the
ithout sockets, and had subcylindrical crowns enamelled
ly.

probable Saurodont, of which the family position cannot be
ned, may be mentioned *Gigantichthys* (*Titanichthys*), founded
eth of very large size, from the Cretaceous of Egypt.

LY GONORHYNCHIDÆ.—We may now briefly mention five
isting families related to the Salmonoids and Clupeoids.
t of these is now represented only by a single species of
nchus found on the coasts of South Africa, Australia, and
Closely allied, however, is *Notogoneus*, from the Eocene of
g, which is mainly distinguished by its dentition.

LY OSTEOGLOSSIDÆ.—The second family is now represented
glossum of South Africa, Sumatra, and Queensland; the
apaima of the Brazilian rivers; and *Heterotis* of several of
South Africa; thus presenting a striking example of discon-

that it should not rather be placed in the allied American fa *Hyodontidæ.*

FAMILY ESOCIDÆ.—The *Esocidæ* are now represented by the P (*Esox*) of the rivers of the Northern Hemisphere. They are cha terised by the margins of the upper jaws being formed by the maxillæ and maxillæ; by the presence of small conical teeth on palate; and the absence of an adipose fin, and the position of dorsal in the hinder part of the body. Species of *Esox* occu the Upper Miocene of Œningen in Switzerland, and the Pleisto of Silesia; while the extinct *Sphenolepis*, of the Upper Eocen Paris and the Eocene of Aix in Provence, characterised by wedge-shaped scales, is considered to be allied. Recent writers place in this family the marine *Istiæus* of the Chalk of Westph and the Lebanon, in which there is a long dorsal fin occupying greater part of the back.

FAMILY SCOMBRESOCIDÆ.—The members of this family mai inhabit tropical and temperate seas, and are best known by the G pike (*Belone*) and the Flying-fish (*Exocœtus*). The jaws are form as in the last family; the dorsal fin is placed above the anal in th caudal region, and there is no adipose fin. *Belone* is found in th Miocene of Licata, in Sicily; while *Holosteus* of the Middle Eoce of Monte Bolca is an allied genus. The living genus *Exocœtus* i characterised by the enormous development of the pectoral fins, an was preceded in the Chalk of the Lebanon by the nearly relate *Exocœtoides.*

FAMILY CYPRINODONTIDÆ.—The Cyprinodonts are mostly smal carp-like fishes, inhabiting the fresh, brackish, or salt waters of considerable part of the world; and readily characterised by the pr sence of scales on the head, and the absence of barbels. Speci of the type genus *Cyprinodon* (*Lebias*) occur in the Middle an Lower Miocene of the Continent, while the Œningen beds hav yielded a species referred to the South American genus *Pœcilia.* comparatively large Cyprinodont has been described from the Pli cene of India.

FAMILY CYPRINIDÆ. — The important family of Carps is ve numerously represented in the freshwaters of the Old World a North America. There are no scales on the head; the margin the upper jaw is formed by the premaxillæ; there are no teeth the jaws; there is no adipose fin; the lower pharyngeal bones ca one or more rows of teeth; and the mouth frequently has barbe The body is more or less compressed, and is often comparativ deep. In the Miocene of the Continent we have representatives the following genera now living in Europe—viz., *Cyprinus* (Car *Gobio* (Gudgeon), *Leuciscus* (Roach and Dace), *Tinca* (Tencl *Rhodeus*, which is mainly Asiatic, *Aspius*, and *Cobitis*. *Acanthops* merican Tertiary forms, which are probably more or less elated to those now inhabiting the same region.

LY SCOPELIDÆ.—The Scopeloids are marine fishes allied to s (with which they agree in the structure of the jaws), in e body may be naked, and there are neither barbels nor dder. They are represented in past epochs by *Hemisaurida*, retaceous of Istria, which is allied to the living *Saurus*, and elus and *Anapterus* from the Miocene of Sicily, of which r is related to *Paralepis* now found in the same region.

LY SILURIDÆ.—The Siluroids or Cat-fishes form a large f freshwater fishes of not less importance than the Carps, g all temperate and tropical regions, and in some cases the sea. The skin is either naked or covered with bony there are always barbels, which frequently have a bony axis; gin of the upper jaw is formed by the premaxillæ; there bopercular; and there may or may not be an adipose fin. ll of the Siluroids is often remarkable for the great develop- the supraoccipital (fig. 938), and the presence of dermal ons in the region of the neck, which spread over the nape, culate with the bones of the secondary pectoral girdle. The l second interspinous bones of the neck frequently also a large bony buckler, behind which the long dorsal spine es by means of a ring with the first interspinal; and this n be fixed in an upright position by a curious mechanism d with the second interspinal. The "helmet" of the nape continuous with the "buckler," and these bones, together se of the cranium proper, are frequently ornamented with a sculpture. The pectoral fins frequently carry a spine as that of the dorsal. The pharyngeal teeth are generally e.

many points in which the Siluroids resemble the Placoder- Ganoids, Professor Huxley has suggested that we may re- latter as nearly related to the ancestors of the existing

Eocene of Barton, we have Siluroids referred to the existing genus *Arius*; the peculiar, somewhat heart-shaped, otoliths of fishes being not uncommon in the Barton beds. It is int to notice the association in the English Eocene of Siluroi Crocodiles and Trionychoid Chelonians; the three groups found together at the present day in India and Africa. The of Sumatra has yielded remains of extinct species of the Oriental genera *Pseudotropius* and *Bagarius*; the last-named being also represented in the Pliocene Siwaliks of India gigantic *B. Yarrelli*, now inhabit Ganges. The same beds have also remains of *Clarias*, now found in b Oriental and Ethiopian regions, of a belonging to the genus *Heterobranc* 938), which is now confined to th and not improbably also of *Chrysic* tropical Africa. The existing *A* *aor* of the Indian and Burmese ri also left its remains in the Siwaliks the characteristic Oriental genus likewise represented in the same d Finally, of the widely-distributed *Arius*, which we have already me from the English Eocene, there is e of two Siwalik species; one bein rently nearly allied to a large existi African form. In the Eocene of America there occurs the genus *Rh* which has vomerine teeth, and i allied either to *Arius* or to *Pi* while spines from the same deposits have been referred latter genus.

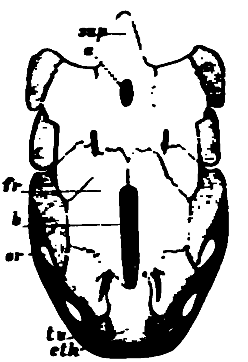


Fig. 938.—Upper view of the skull of *Heterobranchus intermedius*; from the Nile. One-half natural size. *a*, Supraoccipital, and *b*, Frontal vacuities; *eth*, Ethmoid; *fr*, Frontal; *or*, Orbit; *sup*, Supraoccipital; *tu*, Turbinal. The sculpture is omitted.

FAMILY MURÆNIDÆ.—The last family that we have to no this suborder is that of the Eels. In these fishes the body is elongated, and either naked, or covered with rudimental scal toothed maxillæ form part of the border of the upper ja there are no pelvic fins. Of the freshwater forms, *Anguill* ranges from the present date to the Chalk of the Lebanon, abundantly represented in the Miocene of Œningen and the Eocene of Monte Bolca. The Marine forms, or Congers, ar sented by species of the existing genus *Ophichthys* in the Bolca beds; and by the extinct *Sphagebranchus* of the latter d and *Rhynchorhinus* of the London Clay. Peculiar larval fo the type known as *Leptocephali* occur in the Continental Te some of which are probably referable to this family.

SUBORDER 2. ANACANTHINI.—In this and the four following sub-lers, together forming the Physoclysti of some writers, the swim-dder (when present) has no connection with the pharynx, and pelvic fins are nearly always thoracic or jugular in position—in latter case being in advance of the pectorals. The present sub-ler is further characterised by the rays of the dorsal fin being soft d jointed, and the pelvic fin never abdominal.

FAMILY GADIDÆ.—In the Cod family the body (fig. 939) is sym-trical, and covered with small scales; there may be three dorsal

Fig. 939.—The Cod (*Gadus morrhua*). Reduced.

ns, and the pelvic fins are jugular. All the genera are marine, d the family is unknown before the Eocene. The extinct *Nemo-thryx* and *Palæogadus* have been described from the Eocene of Glarus; while in the London Clay of Sheppey we have species

Fig. 940.—Skeleton of *Rhombus minimus*; from the Middle Eocene of Monte Bolca.

llied to *Gadus* (Cod), *Merluccius* (Hake), and *Physis*. Other adoids occur in the Miocene of Sicily.

FAMILY PLEURONECTIDÆ.—The Flat-fishes are characterised by he extreme lateral compression of the body (fig. 940), of which the fore part and the head are not bilaterally symmetrical. They with one side upwards and the other downward, the head twisted round so as to bring the two eyes upon that side becomes the upper one, and which alone is coloured. There swim-bladder, and the dorsal and anal fins occupy almost the length of the body. Remains of a species of *Rhombus* or T (fig. 940) are found in the Middle Eocene of Monte Bolca those of a *Solea* (Sole) in the Miocene of Würtemberg.

SUBORDER 3. PHARYNGOGNATHI. — In this small subord portion of the rays of the dorsal, anal, and pelvic fins is fo by non-articulated spines. The lower pharyngeal bones are ur and the swim-bladder has no duct.

FAMILY POMACENTRIDÆ.—Of this large family the only Eur fossil representative is *Odonteus* from the Middle Eocene of M Bolca, which is allied to the existing *Heliastes;* but Professor thinks that *Priscacara* from the Eocene of North America perhaps be referable to it, although vomerine teeth are present the members of this family have ctenoid scales.

FAMILY LABRIDÆ.—The Wrasses are a large family of l fishes most abundant in tropical and temperate regions, and acterised by their cycloid scales, the single dorsal fin, the th position of the pelvic fins, and the absence of teeth on the p Many of them have the lips greatly thickened; and the phar bones bear molariform teeth. The existing genus *Labrus* is rec from the Middle Eocene of Monte Bolca and the Mioce Switzerland; while *Saurinichthys* of the Miocene of France ap allied to the living *Odacina*. *Proto* of the Eocene of North America i ancestral form of the Black-fish (*Ta* of the same country.

Fig. 941.—Pharyngeal teeth of *Phyllodus* from the London Clay.

FAMILY PHARYNGODOPILIDÆ.—A nu of extinct fishes more or less nearly to the Wrasses, but differing in several very markedly from that family are reg as forming a group by themselves. type genus *Pharyngodopilus* (*Numm tus*) occurs in the French Miocene, a the Tertiary of the Canaries; closely to which is *Phyllodus* from the Creta of Germany and the London Clay of pey, derived teeth being also found i Suffolk Crag. The pharyngeal teeth of *Phyllodus* (fig. 941 remarkable for their thin and leaf-like structure, and also fo rapid manner in which they are succeeded from below by ones. The imperfectly known *Egertonia* from the Lower E

Sheppey, and *Platylæmus* from the Middle Eocene of Brack-
am, may be provisionally included in this family.

FAMILY CHROMIDÆ.—The Chromids are a family of small fresh-
ter Fishes from Palestine, tropical Africa, and America; and also
resented by one genus in India. The scales are usually ctenoid,
lateral line is interrupted, and the teeth of the jaws are very
all. To this family is referred the large genus *Pycnosterinx*
m the Cretaceous of the Lebanon; and with less certainty
gaster of the same deposits.

SUBORDER 4. ACANTHOPTERYGII.—The Acanthopterygii form a
ry large series characterised by part of the rays of the dorsal, anal,
d pelvic fins being non-articulated and forming strong spines. The
wer pharyngeal bones are usually separate; and there is no duct
the swim-bladder. The scales are very generally ctenoid.

FAMILY OPHIOCEPHALIDÆ.—The *Ophiocephalidæ* are freshwater
shes, almost confined to the Oriental region, in which the long
ad and body are entirely covered with scales, and the dorsal and
nal fins are long and devoid of spines. These fishes are in the
abit of burying themselves in the mud during droughts. The type
enus *Ophiocephalus* is represented in the Pliocene of India by
pecies closely allied to, if not identical with some of those now
nhabiting the same area.

FAMILIES FISTULARIIDÆ AND CENTRISCIDÆ.—The first of these
amilies comprises the marine "Flute-mouths," characterised by the
ng body and the production of the anterior bones of the skull
nto a long tube, terminating in the mouth, and by the absence or
mall size of the scales. The existing genera *Fistularia* and *Aulo-
oma*, now found on the borders of the tropical Atlantic and Indian
ceans, are represented in the Eocene of Monte Bolca and Glarus;
hile *Auliscops*, now confined to the Pacific coast of North America,
found in the Eocene of Sumatra. Extinct genera from Monte
olca are *Urosphen* and *Rhamphosus*—the former characterised by
e wedge-like caudal fin, and the latter by a large spiny ray on the
ck. A Fistularian, from the Lebanon Cretaceous, has been named
lenognathus, but the name is preoccupied. The *Centriscidæ*, which
ree with the *Fistulariidæ* in the structure of the mouth, but differ
the form of the body, are known in a fossil state by a species of
e living genus *Amphisile*, from Monte Bolca.

FAMILY MUGILIDÆ.—This and the two next families include
hes characterised by the presence of two distinct dorsal fins, of
ich the first is either low, or has weak spines; and by the ab-
minal position of the pelvic fins, which have five rays and one
ine. The Grey Mullets inhabit the coasts of tropical and tem-
rate seas, and have cycloid scales with no lateral line. The recent
nus *Mugil* occurs in the Upper Eocene of Aix; and *Calamo-*

pleurus, of the European Chalk, with which the North Ameri genus *Syllæmus* is probably identical, may be placed in family.

FAMILY ATHERINIDÆ.—These fishes, which differ from Mullets by the presence of an indistinct lateral line and the g number of the vertebræ, are represented in the Middle Eocene Monte Bolca by two minute species of the existing genus *Atheri* and also by the extinct *Mesogaster*.

FAMILY SPHYRÆNIDÆ.—The Barracudas, in which the late line is continuous and the vertebræ are not numerous, are kno at the present day only by *Sphyræna*, of which some species att a length of eight feet. That genus occurs in the Middle Eocene Monte Bolca, and has also been recorded from the Upper Cre ceous of the Lebanon; but it is probable that the latter form belong to one of the Saurodont Physostomi. *Cladocyclus*, from the Upper Cretaceous of England and Brazil, is an extinct genus.

FAMILY BLENNIIDÆ.—The Blennies form one of four families of but little palæontological importance, in which there is a long dorsal fin, which may be entirely spinous; and the ventrals, if present, are either thoracic or jugular. It is probable that *Pterygocephalus*, from the Middle Eocene of Monte Bolca, should be referred to this family.

FAMILY GOBIIDÆ.—The Gobies belong to another group of the suborder comprising two families, into the characters of which it will not be necessary to enter. They are represented in a fossi state by the existing genus *Gobius*, from the Monte Bolca Eocene and the extinct *Chirothrix*, from the Upper Cretaceous of the Lebanon.

FAMILY DACTYLOPTERIDÆ (*Cataphracti*).—This and the next si families form a group of considerably more interest to the palæon tologist than the preceding. They are collectively known as th Cottoscombriform section, and are characterised by the presence o spines in at least one of the fins; by the dorsal fins being eithe continuous or close together; by the spinous dorsal, when present being short; and when the latter is absent by the length of the sof dorsal. The pelvic fins are always jugal or thoracic. In the preser family the body is cylindrical and elongate, with a coat of bon scutes; the dentition is weak; and the pelvic fins are thoraci *Petalopteryx*, from the Middle Eocene of Monte Bolca, is considere to be related to the existing *Dactylopterus*, in which the pectora are lengthened to an enormous extent.

FAMILY COTTIDÆ.—This family is best known by the freshwat Bull-heads (*Cottus*) and the marine Gurnards (*Trigla*). The bod is more or less oblong; the dentition weak; the dorsal fin is usuall divided, with the soft portion the larger; and the pelvic fins ar thoracic, and generally have five soft rays. *Cottus* itself occurs in the Upper Miocene of Œningen; while the Upper Eocene of Aix yields the extinct *Lepidocottus*, distinguished by its ctenoid scales. *Trigla* occurs in the European Tertiaries.

FAMILY TRACHINIDÆ.—This family comprises a number of genera of small marine Fishes distributed over the greater part of the world, in which the body is long and slender, and may or may not have scales. The dorsal fin may be either single or divided, but its soft portion is always much longer than the spinous. To this family may probably be referred the naked *Callipteryx*, from the Middle Eocene of Monte Bolca; while *Trachinopsis*, of the Upper Tertiary of Spain, is considered to be allied to the existing *Trachinus*—a third extinct genus being *Pseudoeliginus*, of the Sicilian Miocene.

FAMILY SCOMBRIDÆ.—The *Scombridæ*, typically represented by the Mackerels (*Scomber*), but also comprising other pelagic Fishes, are characterised by the oblong and scarcely compressed body, the well-developed dentition, the two dorsal fins, the general presence of finlets in the posterior part of the body, and the thoracic position of the pelvic fins, which have one spine and five rays. In the Miocene and Eocene of Europe, we meet with species of the existing genera *Scomber* (Mackerel), *Thynnus* (Tunny), and *Cybium*, one Lower Miocene species of the latter having been described under the name of *Scomberodon*. Curiously enough, the specialised genus *Echeneis* (Sucking-fishes) is found in the Lower Eocene of Glarus. *Dictyodus* (*Sphyrænodus*) is an extinct genus from the Lower Eocene of England and the Lower Miocene of Belgium, characterised by the strong development of its dentition, and its single row of conical palatine teeth. Other extinct genera are *Palimphyes* and *Isurus*, of the Lower Eocene of Glarus, and *Orcynus*, from the Middle Eocene of Monte Bolca. The existing *Pelamys* has been recorded from the Lower Miocene of Belgium.

FAMILY CORYPHÆNIDÆ.—Another pelagic family allied to the preceding is represented by the well-known Coryphænas, popularly known by the misnomer of Dolphins. The body is compressed; the teeth, if present, are small and conical; and there is a long undivided dorsal fin, without a distinct spinous portion. The existing genus *Mene* (*Gastrocnemus*) is found in the Middle Eocene of Monte Bolca; while the family is also represented by the extinct *Goniognathus*, of the London Clay.

FAMILY CYTTIDÆ.—The Dories have the body very deep and much compressed, with the dorsal fin divided, and its spinous portion taller than the soft part, and the pelvic fins thoracic. They are represented by a species of the existing genus *Zeus*, in the Miocene of Sicily, and also by the extinct *Cyttoides*, of the Lower Eocene of Glarus.

FAMILY CARANGIDÆ.—Of great interest to the palæontologist a
the so-called Horse-Mackerels, on account of the beautiful preser
tion of some of the fossil forms in the Middle Eocene of Mo
Bolca. The body is more or less compressed, and may be oblo
or deep, and either with or without scales. The dorsal fin, whi

Fig. 942.—*Semiophorus velicans*; from the Middle Eocene of Monte Bolca. A, Anal C, Caudal; D, Dorsal; P, Pectoral; V, Pelvic fins.

may be single or divided, has the spinous smaller than the
part; and the pelvic fins, if present, are thoracic. One of the
remarkable extinct genera is *Semiophorus* (fig. 942), in which
dorsal fin is of enormous height, while the pelvic fins are
greatly produced. This genus is known only from the M
Bolca Eocene. Other extinct Tertiary genera are *Pseudovo*

the Miocene of Sicily; *Amphistium* and *Ductor*, from Monte ca; *Archæus* and *Plionemus*, from the Lower Eocene of Glarus; *Æpichthys* and *Vomer*, from the Chalk of Istria. Among exist- genera, *Platax* (fig. 943), popularly known as Sea-Bats, from great height of the fins, occurs in the Red Crag, in the Monte

Fig 943.—*Platax altissimus*; from the Middle Eocene of Monte Bolca. Reduced.

ca Middle Eocene, and in the Chalk of the Lebanon and land. The dorsal fin is single, and the spinous portion is ly entirely concealed, consisting only of from three to seven spines; the jaws are remarkable for their excessive shortness. er living genera found in the Monte Bolca beds are *Zanclus*, *Caranx* (*Carangopsis*), *Argyriosus* (*Vomer*), *Lichia*, and *Trachynotus* and *Equula*, from the Miocene of Sicily.

FAMILY ACRONURIDÆ.—The last family of the Cottoscombriform section comprises tropical marine Fishes, popularly known as Surgeons, which are readily recognised by the sharp spine bordering each side of the tail. The body is compressed, and oblong or ovate, with small scales; the front of the jaws has chisel-like or pointed teeth; and the dorsal fin is undivided, with the spinous portion less than the soft. This family is represented in a fossil state by species of the existing genera *Naseus* and *Acanthurus* from the Middle Eocene of Monte Bolca.

FAMILY TRICHIURIDÆ. — The next section of the suborder is represented by the existing Scabbard-fishes and the extinct *Palæorhynchidæ*. These Fishes are characterised by their elongated, compressed, or band-like bodies, furnished with long dorsal and anal fins, of which the former may be divided into a number of finlets, somewhat after the manner of the Ganoid genus *Polypterus*. All these fishes are marine, and are found in tropical and subtropical seas. Species of the existing genus *Lepidopus* (Scabbard-fish) occur in the Miocene of Sicily, while *Hemithyrsites* and *Trichiurichthys*, of the same deposits, are forms allied to the living *Thyrsites* and *Trichiurus*, but differing by having the body scaled. *Xiphopteryx* is another extinct genus from the European Eocene; while *Anenchylum*, of the Lower Eocene of Glarus, resembles *Lepidopus* except for the presence of some long rays in the pelvic fins, and the two are probably identical.

FAMILY PALÆORHYNCHIDÆ.—The members of this family differ from the last by the production of the jaws into a long rostrum, which is either edentulous or provided with very small teeth. The dorsal fin occupies the whole length of the body, and the anal is also elongated and reaches nearly to the forked caudal. This family is known only by *Hemirhynchus* from the Eocene of the Paris basin, and *Palæorhynchus* from the Lower Eocene of Glarus.

FAMILY XIPHIIDÆ.—The Sword-fishes, which are of pelagic habits, and generally attain very large dimensions, are characterised by the production of the upper jaw into a long spear-like rostrum. They are represented at the present day by *Xiphias* (fig. 944), in which pelvic fins are wanting; and *Histiophorus*, in which these organs are long and filiform, and the dorsal fin may be of great length and height. Fossil Sword-fishes from the London Clay have been referred to *Histiophorus* (*Tetrapturus*), although it is not certain that they may not prove generically distinct. The genus *Cœlorhynchus*, which was formerly referred to this family, is noticed among the Chimeroidei.

FAMILY BERYCIDÆ.—The *Berycidæ* are characterised by the presence of mucous-bearing cavities in the head, and by the pelvic fins having (except in *Monocentris*) a single spine, and more than five rays. This family is one of the oldest of the suborder, being abundantly represented in the Chalk. The fossil genera, which may be noticed in alphabetical order, are as follows—viz., *Acrogaster*, from the Upper Cretaceous of Westphalia; *Berycopsis*, from the Creta-

Fig. 944.—*Xiphias.* Greatly reduced.

ceous of England; *Beryx*, in which there is one dorsal fin with several spines, is represented by a single species in the European Chalk, and by two species in the Chalk of the Lebanon, while it is also living at the present day; *Holocentrum*, from the Middle Eocene of Monte Bolca, the Miocene of Malta, and tropical seas of the present day; *Homonotus*, from the Cretaceous of both England and the Lebanon; *Hoplopteryx* (fig. 945), in which the spinous portion of the dorsal fin is greatly developed, and there are also four

Fig. 945.—*Hoplopteryx lewesiensis*; from the Upper Chalk of Sussex. Reduced. (After Mantell.)

large spines in advance of the anal, is known from the Upper Cretaceous of both Europe and the Lebanon; *Myripristis*, from the Middle Eocene of Monte Bolca, and now found in tropical seas; *Pristigenys*, from Monte Bolca; *Pseudoberyx*, from the Chalk of the Lebanon, characterised by the almost abdominal position of the pelvic fins; *Sphenocephalus*, from the Upper Cretaceous of Westphalia; and *Stenostoma*, from the English Chalk, of which the affinity is somewhat doubtful.

PERCIFORM SECTION.—The remaining families of this suborder are characterised by their more or less compressed body; by the dorsal fin, or fins, occupying the greater portion of the back; by the strong development of the spinous part of the dorsal fin, which is at least as long as the soft portion; and by the soft anal corresponding to the soft dorsal. The pelvic fins are thoracic.

FAMILY SCORPÆNIDÆ.—This family, which is allied to the following, but has villiform teeth, is known in a fossil state only by a species of the type genus *Scorpæna*, from the Eocene of Algeria.

FAMILY SPARIDÆ. — The Sea-Breams resemble the Percoids, which we shall notice immediately, in general appearance, but the mouth is either provided in front with chisel-like teeth, or on the sides with molariform ones. All of them inhabit tropical and temperate seas. Among existing genera the sphæroidal palatal teeth of *Chrysophrys* occur in the Red Crag of Suffolk, the Miocene of Malta, and in beds in the Canaries, which are probably referable to the same epoch; while *Sargus* is recorded from the Miocene of France and Würtemberg, the Upper Eocene of Algeria, and the older Tertiary of New Zealand; and *Pagellus* occurs in the Chalk of the Lebanon. It appears, moreover, that many of the crushing palatal teeth of *Chrysophrys* have been described as *Sphærodus*, while the anterior cutting-teeth of the same genus, together with pharyngeal teeth of some of the Carps, have been described as *Capitodus*.

Fig. 946.—Skeleton of *Sparnodus micracanthus*; from the Middle Eocene of Monte Bolca. Reduced

Cutting-teeth of this type, described under the latter name, occur in the Miocene of Austria and Silesia, the Pliocene of Italy, and the Eocene of Northern India. *Sparnodus* (fig. 946) is an extinct genus from the Middle Eocene of Monte Bolca, while the name *Stephanodus* has been applied to a genus from the Upper Chalk of the Sahara, characterised by the breadth and denticulated edges of the cutting-teeth. It may also be observed that teeth from the European

Tertiaries have been described under the names of *Sargodon*, *Soricidens*, and *Asima*.

FAMILY CHÆTODONTIDÆ. — The Coral-fishes, or Chætodonts, differ from the Percoids in the greater vertical depth of the body, by the continuation of the scales over the median fins, and also by the lateral line stopping short of the caudal fin. Their teeth are bristle-like. These marine tropical fishes (which are generally described under the name of *Squamipennes*) are remarkable for the extreme gorgeousness of their colouring, and are of comparatively small size. They are represented in the Middle Eocene of Monte Bolca by the existing genera *Holacanthus*, *Pomacanthus*, *Ephippus*, *Scatophagus*, and *Toxotes*; the latter being now confined to the Oriental and Australian regions. The earliest Chætodont is *Platycormus*, of the Upper Cretaceous of Westphalia.

FAMILY PERCIDÆ.—With this and the next family of highly specialised Fishes we come to the end of the existing representatives of the present suborder. These Fishes are characterised by the continuous lateral line (fig. 947), the general absence of scales from the median fins, the conical teeth, and the absence of barbels. They are all carnivorous, and inhabit the freshwaters and coasts of

Fig. 947.—The Common Perch (*Perca fluviatilis*). Reduced.

all tropical and temperate regions. The existing genus *Perca* (Perch) occurs in the Upper Miocene of Œningen; while in the Upper Eocene of Aix we have the allied but extinct *Paraperca*. In the Middle Eocene of Monte Bolca, we find species referable to the existing genera *Labrax* (Bass); *Lates*, now inhabiting the Nile and Ganges; *Dules*, of the Indo-Pacific; *Serranus* (Sea-Perch); *Apogon*, of the Mediterranean and Atlantic; and also *Therapon*, of the Indo-Pacific. The extinct *Cyclopoma* and *Smerdis* (fig. 948) likewise occur in the same deposits; the latter being also found at Aix and in the Miocene of Würtemberg. *Acanus* and *Podocys*, from the Lower Eocene of Glarus, are members of this family, which were formerly referred to the *Berycidæ*. In the Eocene of North America we have *Mioplosus*, presenting characters common to

Ancistrodon, founded upon detached teeth from the Chalk
France; similar teeth also occurring in the Cretaceous of Te
These teeth are generally regarded as pharyngeal teeth of Teleos
although it has been suggested that they may prove to be ante
teeth of Pycnodont Ganoids.

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CHAPTER LI.

CLASS AMPHIBIA.

GENERAL STRUCTURE AND ORDERS.

THE Amphibia, which comprise the Frogs and Toads, Salamandr
Cæcilians, and the extinct Labyrinthodonts, and are someti
known as the Batrachia, agree in so many points of structure with
more generalised Fishes, that Professor Huxley groups the two cl
together under the common name of Ichthyopsida. Recent obse
tions on fossil forms, tend, however, to show in the other direc
a transition from the Amphibia to the more generalised Repti
The Amphibia as a whole differ from Fishes mainly by the circu
stance that when median fins are present they are devoid of fi
rays; and that the limbs, when present, contain the same skele
elements as those of the higher classes. They agree with Fishes in
having branchiæ in their earlier stages of life, but these very fre
quently disappear in the adult, when respiration is carried on entirely
by means of the lungs. An epidermal exoskeleton is generally
wanting. There is no amnion, and at best but an imperfect allantois
in the embryo. In existing forms the cranium always articulates to
the vertebral column by two distinct exoccipital condyles, but in a few
Labyrinthodonts these were not ossified. The mandible articulates
to the cranium without the intervention of a suspensorium; so that
the skull, like that of the Dipnoid Fishes, is autostylic. A large para-
sphenoid is always present; and cranial bones are largely developed,
although their number is generally less than in Fishes. The external
nares are terminal in nearly all cases. The vertebral column is
more or less completely ossified, and can generally be differentiated
into cervical, dorso-lumbar, sacral, and caudal regions; the sacrum
but rarely comprising more than a single vertebra. The infraneural
segments of the vertebral column are frequently amphicœlous, and
in recent forms each bears its own arch; but in certain Labyrintho-
donts, as we shall see below, the neural arches are carried by alte

ate vertebral segments, and from circumstances to be detailed in the sequel it is inferred by Professor Cope and others that the vertebral bodies of existing Amphibians are really intercentra, carrying the neural arches which have been shifted to them from the lost centra. The ribs may articulate to the vertebra by a single (upper) transverse process; but in Salamandroids and Labyrinthodonts the vertebræ also carry an inferior rib-facet, when the heads of the ribs are consequently double. As a rule no ribless (lumbar) vertebræ occur, and sternal ribs are wanting. The sternum, which is never present in Fishes, appears in the Amphibia in the middle line of the chest, and may be extended anteriorly as an omo- and episternum (fig. 974, B). The pectoral and pelvic girdles are well developed; the former (*ibid.*) in recent forms having, however, no clavicle or interclavicle, although it is nearly certain that these bones are represented in the thoracic buckler of the Labyrinthodonts. A distinct rod-like precoracoid (fig. 974, B) occurs in recent forms. In the pelvis the pubis is frequently unossified, and if ossified is much smaller than the ischium. In most cases the ischium and the cartilaginous or bony pubis of either side unite to form a continuous plate, in which the obturator foramen is not represented, although there is a small perforation; and the ischia meet in a ventral symphysis. The body of the ilium may be almost wholly in advance of the acetabulum. The limbs vary greatly in their proportionate length in the different orders, and may be entirely absent; while the carpals and tarsals may be unossified. The limb bones of the Labyrinthodonts approximate to those of the Anomodont Reptiles. The carpus and tarsus always have a centrale, and in some of the primitive Labyrinthodonts there may be at least three centralia in the latter. The fourth and fifth tarsalia always remain distinct from each other in those forms which have five digits. The latter number is found in the Labyrinthodonts, but in some existing forms the digits may be reduced to three or two. The number of the phalangeals in the digits of pentedactylate forms, counting from the first to the fifth, does not exceed 2, 2, 3, 3, 3, and this number may be reduced in some existing forms. As a rule the tail is comparatively short.

Teeth are usually present on the premaxilla, maxilla, vomer, and the dentary bone of the mandible; but are generally wanting on the palatine and pterygoid, although present on the latter, and also on the parasphenoid, in many Labyrinthodonts. These teeth are usually anchylosed to the bone, and in existing forms are of simple structure. In the Labyrinthodonts the structure of the teeth may, however, become very complex by foldings of the dentine, this structure being an extreme development of that met with in certain Ganoids; and in some of these forms the usually large pulp-cavity may be greatly reduced. In existing forms there is generally no exoskeleton, and if scutes or scales are developed they are buried in the skin; but in the Labyrinthodonts bony scutes were very generally present, although frequently restricted to the ventral aspect of the body.

A marked, although not universal, feature in the class is the change from a respiration by gills to one by lungs; this change being accompanied by other structural alterations, and termed a metamorphosis. In some instances only external gills are developed, which form a plume on either side of the neck; and it is these gills which persist in such forms as do not undergo a metamorphosis. In those groups, however, in which a metamorphosis takes place internal gills may be developed for a short period.

That the Amphibia have taken their origin from primitive Fishes allied to the Dipnoi and Ganoidei is pretty evident. Evidence of

Fig. 950.—Enlarged view of the upper surface of the cranium of *Protriton*, with the characteristic Labyrinthodont bones shaded; from the Permian of Bohemia. *N*, Nasal; *F*, Frontal; *P.a*, Parietal; *S.O*, Supraoccipital; *E.p*, Epiotic; *S.T.*, Supratemporal; *S.q*, Squamosal; *P.t.f*, Postfrontal; *Ju*, Jugal; *P.t.o*, Postorbital; *im*, Premaxilla; *M.S*, Maxilla; *QJ*, Quadratojugal; *Q*, Quadrate. (After Fritsch.)

affinity with the primitive Ganoids is indeed very clearly shown by the so-called labyrinthic structure of the teeth of nearly all the Palæozoic Amphibia, since we find a similar type of dental structure obtaining in many of the early Ganoids, and nowhere else in the whole animal kingdom. The similarity in the structure of the vertebral column of the earlier Elasmobranch and Ganoid Fishes with that of the Labyrinthodont Amphibians is also important evidence pointing in the same direction.

This class may be divided into the four orders, Labyrinthodontia, Apoda, Ecaudata, and Caudata. The first is totally extinct, the second is at present unknown before the existing epoch, while we have no certain record of the occurrence of the third before the Cretaceous, and of the fourth previously to the Tertiary.

ORDER I. LABYRINTHODONTIA.—Since the name of this order is not strictly applicable to all its members it has been proposed to substitute the term Stegocephala; but, as the same objection might be taken to a large number of terms in use, such a change seems unnecessary. Using, then, the Labyrinthodontia as including the Ganocephala and Microsauria of some writers, its members may be characterised by the following features. The body is more or less elongated, and furnished with a tail; the skull has paired supraoccipitals (fig. 950, *S.O*), and its postero-lateral regions are roofed over by a postorbital (*P.t.o*) anteriorly, and a supratemporal (*S.T*) posteriorly. There is, moreover, very generally an epiotic[1] (*E.p*); the orbits frequently have a bony ring in the sclerotic; and there is a

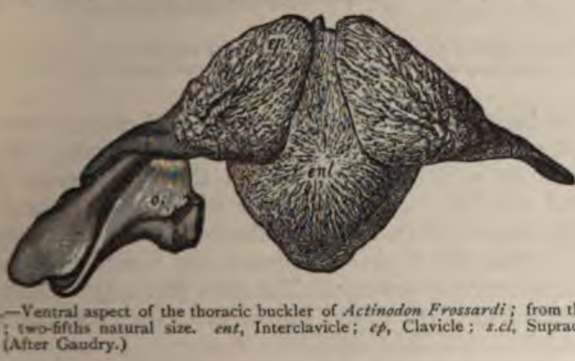


FIG. 951.—Ventral aspect of the thoracic buckler of *Actinodon Frossardi*; from the Permian of France; two-fifths natural size. *ent*, Interclavicle; *ep*, Clavicle; *s.cl*, Supraclavicle; *o*, Scapula. (After Gaudry.)

parietal foramen. Palatine and vomerine teeth are very generally present, and the dentine of the teeth is frequently more or less folded, or plicated, from the sides. The centra of the vertebræ, which are amphicœlous, may be imperfectly ossified, and frequently retain a notochordal canal in the middle. Usually there is a buckler on the inferior surface of the thorax, consisting of one median, and two lateral flattened bones, probably representing the interclavicle and clavicles; the relations of these bones being shown in fig. 951.

[1] Dr Baur regards this bone as the opisthotic; and also considers that the bone here termed the squamosal is the supratemporal, and *vice versâ*.

Posteriorly to this thoracic buckler an armour of dermal scutes is generally developed on the ventral surface of the body; and in some cases this armour may cover the entire body, the form of the scutes, or scales, then varying considerably in the different regions. Four paired pentedactylate limbs were usually present.

The pterygoids are always separated from one another in the median line. The pelvis[1] of the more typical forms is remarkably like that of the Pariasaurian Anomodont Reptiles, presenting the same absence of an obturator foramen.

The paired supraoccipital ossifications constitute a feature found elsewhere only among the Ganoid Fishes; and the frequent ossification of the articular bone of the mandible is also a character not found elsewhere in the class. In many cases the external surface of the bones of the skull (fig. 952), and of the thoracic buckler, is

Fig. 952.—Lateral view of the imperfect left ramus of the mandible of *Pachygonia incurvata*; from the Lower Mesozoic of India. The letters indicate mucous canals. (After Huxley.)

sculptured by a series of irregular grooves and ridges; traversed in the former instance by a number of mucous canals. From the occurrence of a similar sculpture in the Pariasaurian Anomodonts and the Crocodilians, Professor Seeley regards these groups as directly descended from Labyrinthodonts; and it is evident that the passage from the Labyrinthodonts to the former group of Reptiles is almost a complete one. The gills (fig. 953) of the young are generally lost in the adult; but in one group the external gills persist.

Labyrinthodonts range in Europe generally from the Carboniferous to the Trias, and are especially abundant in the Permian; but one genus (*Rhinosaurus*) persisted to the Lower Jurassic. In North America and India this order is abundantly represented in strata mainly representing the period from the Carboniferous to the Trias. According to the views of Professor Cope and Dr Fritsch, this order is to be regarded as one presenting generalised characters, some of which approximate to those of modern Amphibia, while others are

[1] It should be observed that in the figure of the pelvis of *Eryops* given in Zittel's 'Palæontologie,' abth. i., vol. iii., pt. ii., p. 364, fig. 351, the hinder end of the ischium is mistaken for the pubis.

ın; and we may probably regard the Anomodont Reptiles ıg taken their origin from a group closely allied to the Laby-onts, if not actually from this order. As regards the sub-s of the order there is still considerable uncertainty, and all visions must consequently be regarded as more or less pro-. Dr Fritsch has, indeed, proposed to range the families our series or suborders, according to the external contour of ly and the nature of the vertebral column; this grouping rovisionally adopted in the present work, with some emenda-nomenclature.

RDER I. BRANCHIOSAURIA.—In this suborder the external nce approaches that of the modern Salamanders. The ver-ave centra composed of a single piece, which retains traces notochord; the ribs are short and straight; and the neural s dilated in the middle of each vertebra. The teeth are in structure, and internal gills were developed in the young. uthorities include the next two groups in the present sub-nder the name of Lepospondyli.

LY PROTRITONIDÆ.—The *Branchiosauridæ* of Dr Fritsch, ounded on a name which is apparently a synonym, may be known as the *Protritonidæ*. They are characterised by the readth of the skull (fig. 950), and the smooth teeth. Typi-e palatines, according to Dr Credner, are small transversely ed bones lying in the r part of the skull, and ning the maxillæ; this ment being similar to und in the Ecaudata. type genus *Protriton hiosaurus* or *Pleuron-* found abundantly in rmian of the Continent; development has been orked out by Dr Cred-m the study of a large r of specimens of all The specimen shown 953 exhibits the nearly skeleton of a small individual, while the details of the cra-ucture are exemplified in the greatly enlarged skull shown 950.

Fig. 953.—Ventral aspect of the nearly entire skeleton of a young individual of *Protriton petrolei*; from the Permian of France. (After Gaudry.)

rding to the observations of Dr H. Credner, it appears that ngest specimens known were 25 mm. in length, in which stage ature was aquatic, and breathed by gills, which were supported pairs of arches. By the time they attained a length of from 60 to 70 mm., these larvæ cast their gills, and became air-breathers; development being thus analogous to that of the existing Salaman The adults measure from 100 to 160 mm. In the course of the morphosis the skull decreases somewhat in width, and the the buckler grows much more rapidly than the scapula and coracoid, curiously enough, the pelvis shifts its position, and thus increase number of presacral vertebræ from 20 to 26. In the larva the side of the body is naked (fig. 953), but in the adult there is a com armour of bony scutes on this aspect.

Other genera of which some may perhaps be included in family are *Amphibamus*, from the Carboniferous of Illinois; *P* from that of Ohio; *Batrachiderpeton*, from the Carboniferous Britain; *Hylerpeton*, from that of Nova Scotia; *Dawsonia*, the Permian of Bohemia; and *Sparodus*, from the latter depo *Batrachiderpeton* is remarkable for the absence of maxillary tee and the clustering of the palato-vomerine teeth; *Sparodus* prese ing the latter feature, but retaining the maxillary teeth. The pal tines of the latter genus are splint-like bones interposed between th vomers and maxillæ.

FAMILY APATEONIDÆ.—In this family the skull (fig. 954) is tri angular and comparatively narrow, while the teeth are marked by small grooves at their summits. The type genus *Apateon* is found in the Carboniferous rocks of Germany, while the allied *Melanerpeton* is from the Permian of Bohemia. An enlarged view of the dorsal aspect of the skull of the latter genus is shown in fig. 954, the retention of the internal gills indicating that it belonged to an immature individual.

SUBORDER 2. AÏSTOPODA.—In this remarkable group the body has a snake-like form, with well-developed ribs, but probably without either pectoral or pelvic girdles or limbs. The teeth are not folded; and Dr Fritsch considers that the external gills persisted throughout life.

FAMILY DOLICHOSOMATIDÆ.—This family, which is equivalent to both the *Plegothonidæ* and *Molgophidæ* of Professor Cope, is represented in the Carboniferous of Britain and the Permian of Bohemia by *Dolichosoma* and *Ophiderpeton*. In the former the skull is long and narrow, with no sculpture on the bones, and it is probable that the body was entirely naked; but in the latter the skull may have been shorter, and there was an armour on both surfaces of the body, the scutes on the ventral side being long oat-like splints, while those on the back were rounded and shagreen-like. The ossified gill-supports were furnished with small enamel-like denticules. One of the species of *Dolichosoma* attained a length of about two feet. *Plegethontia* and *Molgophis*, from the Carboniferous of Ohio, appear to be nearly related. *Palæosiren*, from the Permian of Bohemia, is a gigantic form provisionally included in this family of which the length is estimated at forty-five feet; while *Adenoderma* of the same deposits may indicate a distinct family.

From the many resemblances presented by the *Dolichosomatidæ* to the existing Apoda, Dr Fritsch considers it probable that they must be regarded as nearly related to the ancestral forms from which that group has been derived.

SUBORDER 3. MICROSAURIA.—The Labyrinthodonts included in this suborder resemble Lizards in outward appearance, and have the centra of the vertebræ more or less elongated, and long, curved ribs.

FAMILY UROCORDYLIDÆ.—This family—the *Nectridea* of Professor Miall and the *Ptyoniidæ* of Professor Cope—comprises stout, long-

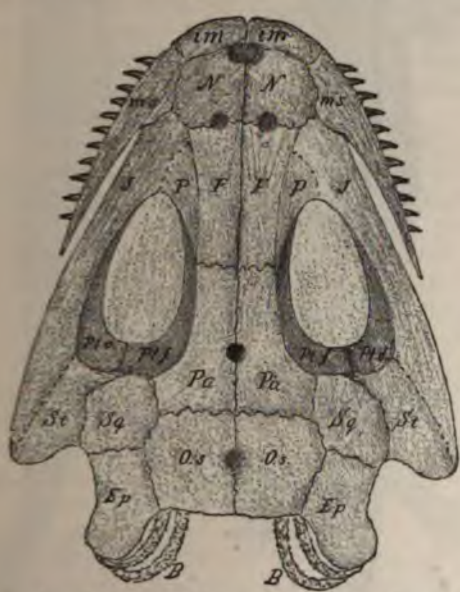


Fig. 954.—Upper surface of the skull of *Melanerpeton pusillum*; from the Permian of Bohemia; six times natural size. *B*, Branchiæ; *O.s.*, supra-occipital; other letters as in fig. 950. (After Fritsch.)

tailed forms, in which the epiotic cornua of the skull are much produced; the cranial bones are pitted; the neural spines and chevrons of the caudal vertebræ are much dilated at their extremities and pectinated; and caudal ribs are wanting. The type genus *Urocordylus*, as well as *Ceraterpeton*, occurs in the Carboniferous of Britain and Ohio, and also in the Permian of Bohemia; one species of the former attaining a length of about twenty inches. *Lepterpeton* is characteristic of the Carboniferous of Britain and Ohio; other genera from the latter deposits being *Ptyonius*, *Œstocephalus*, *phasma*, and probably *Sauropleura*.

FAMILY LIMNERPETIDÆ.—In the one genus *Limnerpeton*, of Permian of Bohemia, the naked body is more elongated and the shorter than in the preceding family; the skull being broad

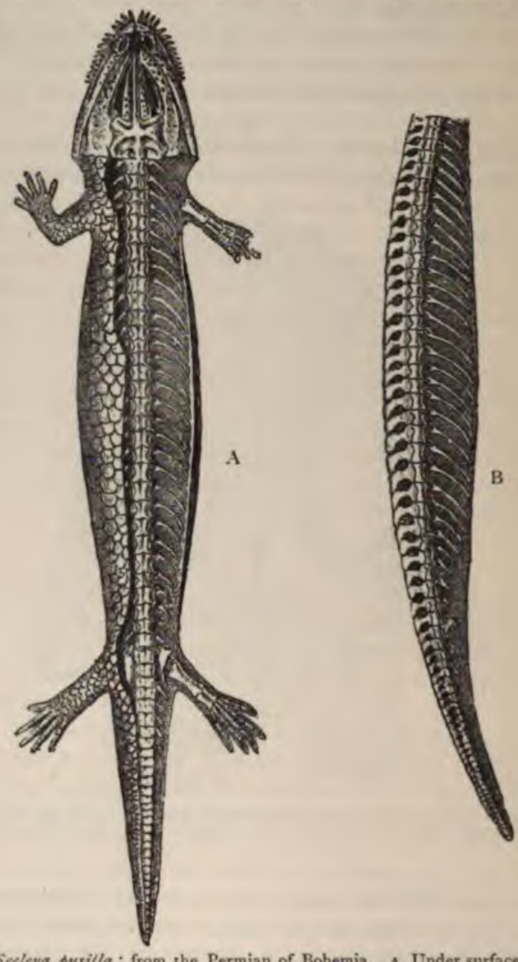


Fig. 955.—*Seeleya pusilla*; from the Permian of Bohemia. A, Under surface with sc moved on the left side; and B, Right lateral view of the skeleton of the caudal region. Enl (After Fritsch.)

Frog-like, with smooth bones; and the upper and lower proc of the caudal vertebræ simple. The teeth are small, with their mits either smooth or folded.

FAMILY HYLOPLESIONIDÆ.—This family is readily recognised by the somewhat narrow head, the smooth cranial bones, and the envelopment of the whole body (fig. 955, A) in an armour of scutes. The caudal ribs (fig. 955) are well developed. It comprises the genera *Hyloplesion*, *Seeleya* (fig. 955), *Ricnodon*, and *Orthocosta*, from the Permian of Bohemia. *Hylonomus* and *Smilerpeton*, from the Carboniferous of Nova Scotia, are imperfectly known forms which may belong to the same family, in which case the name *Hylonomidæ* might be adopted. All the species are of small size.

FAMILY MICROBRACHIDÆ.—This family includes small slender forms, with short pectoral limbs, strongly sculptured cranial bones, and scutes covering the entire body. The type genus *Microbrachis* occurs in the Permian of Bohemia, and has a long narrow skull. Three species are known. Another representative of this family is *Tuditanus*, of the Carboniferous of Ohio, characterised by its broad and expanded skull. *Cocytinus*, of the same deposits, may be provisionally placed in this family.

SUBORDER 4. LABYRINTHODONTIA VERA.—The genera included in this group are characterised by their Crocodile-like bodies; the disk-like centra of the vertebræ, when these are fully ossified; by the vertebral column being, at least in the young, very generally of the types known as *rhachitomous* and *embolomerous;* by the teeth being more or less folded; and by the outer surface of the skull bearing a more or less strongly-marked sculpture, frequently accompanied by the presence of the so-called mucous canals. Some authorities divide this group into the *Temnospondyli* and *Stereospondyli*, according to the incomplete or complete ossification of the vertebral centra; but Dr Fritsch regards the whole series as constituting a single group—a view which is supported by the circumstance that in many of those forms in which the vertebræ are fully ossified in the adult, in the young stage their ossification is incomplete.

Before proceeding further it will be advisable to briefly consider the nature of the above-mentioned types of vertebral structure. In certain genera like *Diplospondylus*[1] (*Diplovertebron*) and *Cricotus* each caudal vertebra consists of an anterior centrum carrying the neural arch, and a posterior intercentrum to which the chevrons are united. These intercentra, according to the views of Professor Cope, correspond with the chevron-bearing intercentra of *Clepsydrops* among the Anomodont Reptilia, and the wedge-bones of *Sphenodon* among the Rhynchocephalians; this type of structure being known as the *embolomerous*. In the trunk vertebræ of other genera like *Trimerorhachis* (fig. 957) and *Archegosaurus* each vertebra (fig.

[1] This name has been proposed in lieu of the hybrid *Diplovertebron*.

956) consists of four portions—viz., a basal intercentrum (hypocentrum), a pair of pleurocentra, and a neural arch. In this *rhachitomous* type Professor Cope regards the pleurocentra as representing the centrum of the embolomerous type, since they both carry the arch; and as he finds that the functional centra in other forms, like *Chelydosaurus*, apparently correspond to the intercentra of *Archegosaurus*, while the pleurocentra are small and apparently about to disappear, it is argued that in other Amphibia the real centra are totally wanting, and the vertebral bodies, which in the caudal region have the chevrons united to them, are really intercentra, to which the neural arches have been shifted. Professor Cope regards the rhachitomous and embolomerous structures as characters of at least family value; but Dr Fritsch considers that the two types occur in different regions of one and the same species, as we

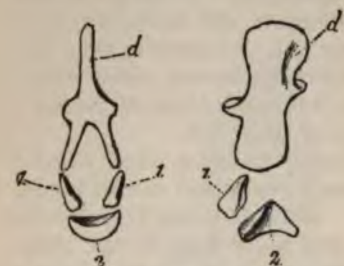


Fig. 956.—Diagram of a rhachitomous vertebra; from the front and left side. 1, Pleurocentra; 2, Intercentrum; *d*, Neural spine. (After Fritsch.)

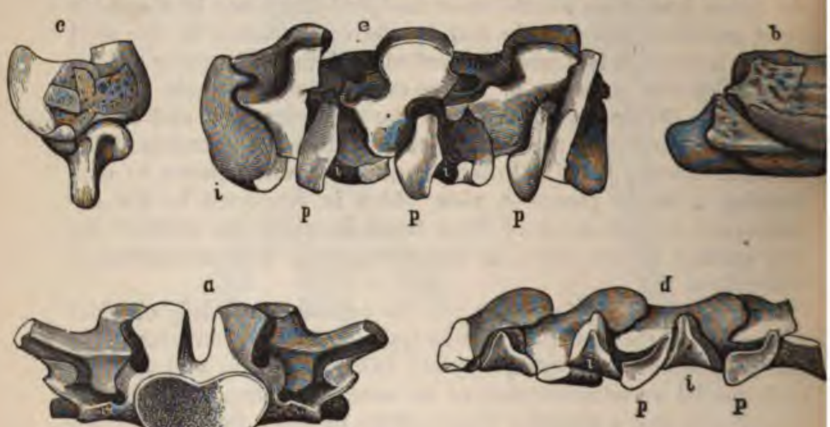


Fig. 957.—Parts of skull and vertebral column of *Trimerorhachis insignis*; from the Permian of North America. *a*, Basi- and exoccipitals; *b*, *c*, Lateral and posterior view of angle of mandible; *d*, *e*, Portions of vertebral column depressed by pressure; *i*, Intercentra; *p*, Pleurocentra. (After Cope.)

know to be the case in some of the Ganoid Fishes (*supra*, p. 959), where we find in *Eurycormus* and *Aspidorhynchus* a rhachitomous type of vertebræ in the cervical and dorsal regions, and an embolmerous type in the caudal. An excellent example of the rhachitomous type of vertebra is shown in fig. 960, the pleurocentra being omitted.

It should be observed that this interpretation of the homology of the rhachitomous vertebra is not accepted by Mr Hulke.

FAMILY ARCHEGOSAURIDÆ. — The well-known genus *Archegosaurus*, ranging in Europe from the Carboniferous to the Permian, may be taken as the type of a family, which for the present may include most of those forms in which the dorsal vertebræ are of the

Fig. 958.—Upper surface of the cranium of *Archegosaurus*; from the Carboniferous. Reduced. *Pmx*, Premaxilla; *Mx*, Maxilla; *Na*, Nasal; *La*, Lachrymal; *Fr*, Frontal; *PF*, Prefrontal; *Pa*, Parietal; *PtF*, Postfrontal; *PtO*, Postorbital; *Ju*, Jugal; *QJ*, Quadratojugal; *Sq*, Squamosal; *ST*, Supratemporal; *Ep*, Epiotic; *SO*, Supraoccipital. (After Miall.)

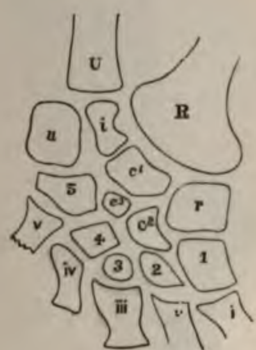


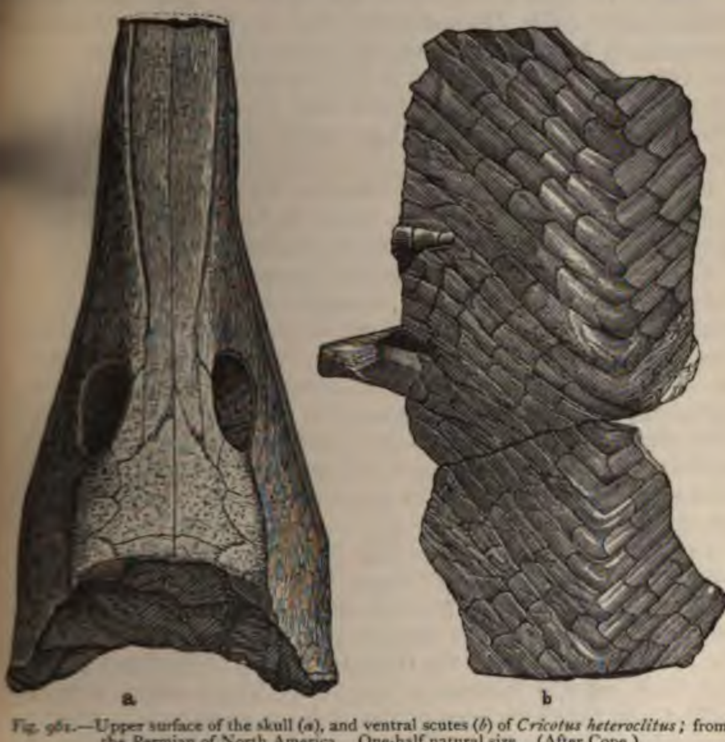
Fig. 959.—Upper aspect of the right carpus of *Eryops*; from the Permian of North America. Reduced. *R*, Radius; *U*, Ulna; *r*, Radiale; *i*, Intermedium; *u*, Ulnare; c^1, c^2, c^3, Centralia; 1-5, Carpalia; i.-v., Metacarpals (After Baur)

rhachitomous type throughout life. Its members have, indeed, been split up into the *Melosauridæ*, *Trimerorhachidæ*, and *Eryopidæ*; but the observations of Dr Fritsch indicate that for the present at least such divisions are not definable. According to the last-named authority this family may be characterised as including Labyrinthodonts of medium dimensions; having cylindrical teeth of varying size, in which the folding of the dentine is comparatively slight; the upper surface of the skull being pitted; the supraoccipitals ridged; and the trunk vertebræ rhachitomous, and the caudal usually embolomerous. A ring of bones is usually developed in the sclerotic; the ventral surface of the body is always covered with scutes; and the palatines form long splints lying on the inner of the maxillæ. This family is evidently the most primitive of the entire order; the vertebral column displaying an arre development at a stage which is transitional in higher forms. further remarkable for the small size of the coracoid, in which re this group agrees with the Salamanders and some of the An dont Reptiles. The humerus has distinct condyles, as in the group; and in the pelvis the pubis is ossified, and, like that of Anomodonts, unites with the ischium without the interventi an obturator foramen. The tarsus and carpus (fig. 959

Fig. 960.—Left lateral aspect of the arch and intercentrum, and posterior aspect of t of a dorsal vertebra of *Euchirosaurus Rochei*; from the Lower Permian of France. *n*, spine, with lateral expansions, *al*; *s*, Suture between spine and arch; *z.a*, Pre-, *z.p*, P pophysis; *d*, Transverse process; *c*, Rib-facet; *c.r*, Neural canal; *i.c*, Intercentrum. (from Gaudry.)

characterised by the number of centralia, there being, acco to the interpretation here followed, four of these bones in former and three in the latter; and the first centrale articu respectively with the tibia in the tarsus and with the radi the carpus. This type of tarsal and carpal structure is evic the most primitive yet observed.

In *Archegosaurus*, and also in *Zygosaurus* of the European mian, and *Trimerorhachis* of the reputed equivalent strata of America, the occipital condyles were not ossified; but they ony in many of the other genera. The following genera from the Permian of Europe have vertebræ agreeing in structure with those of the typical forms, and may be provisionally placed in the same family; they are named *Melosaurus*, *Osteophorus*, *Zygosaurus*, *Chelydosaurus*, *Cochleosaurus*, *Gaudrya*, *Actinodon*, and *Euchirosaurus*. *Sphenosaurus*, from the Permian of Bohemia, has also been placed here, although some writers regard it as a Reptile. The name *Discosaurus* has also been applied to a member of this group from the



a b

Fig. 961.—Upper surface of the skull (*a*), and ventral scutes (*b*) of *Cricotus heteroclitus*; from the Permian of North America. One-half natural size. (After Cope.)

Permian of Dresden, but it is preoccupied in the Sauropterygia. Portions of a vertebra of *Euchirosaurus*, from Autun in France, are shown in fig. 960, the neural spine being remarkable for the great lateral expansion of its summit; according to Dr Fritsch's restoration (fig. 956) the pleurocentra belonging to this vertebra would be on the anterior side, but Dr Zittel would rather regard those on the posterior aspect as referable to this segment of the column. In the Bijori stage of the Lower Gondwanas of India this group is represented by *Gondwanosaurus;* while, if we may judge by detached intercentrum which may belong to it, *Rhytidosteus*, of Karoo system of South Africa, should also find a place here. T American Permian, in addition to *Trimerorhachis*, has also yield *Zatrachys*, *Eryops*, *Acheloma*, and *Anisodexis*. *Eryops* includes w large species, in which the nares are widely separated and placed at the extremity of the snout, and the thoracic plates not sculptured.

FAMILY DIPLOSPONDYLIDÆ.—This family[1] is proposed by Fritsch for the genus *Diplospondylus*, from the Permian of Bohem characterised by the embolomerous structure of the entire ve bral column, and the absence of pits on the skull. *Cricotus* (961), from the Permian of Illinois and Texas, appears to be allied form, which Professor Cope makes the type of the fan *Cricotidæ*.

Finally, it may be mentioned here that the genus *Ichthyacanth* from the Carboniferous of Ohio, which is frequently placed in Microsauria, is described as having rhachitomous vertebræ.

FAMILY NYRANIIDÆ.—The genus *Nyrania*, from the Permian Bohemia, of which the skull is shown on an enlarged scale in fi 824, 825 (pp. 902, 903), differs from *Archegosaurus* in that the pa tines, in place of forming splints on the inner side of the maxil are situated near the middle line, internally to the vomers a pterygoids, and would therefore seem to represent a distinct fami This arrangement of the bones of the palate is similar to th obtaining in the existing Caudata. Some of the genera notic among the *Archegosauridæ*, in which the skull is unknown, m belong to this family.

FAMILY DENDRERPETIDÆ.—This family, which may be taken include the Brachiopina of Professor Miall, contains several gene of which the precise serial position and full affinities are at pres somewhat uncertain. The skull is parabolic, and marked by de pits; the parasphenoid in the type genus has a short stem; and teeth have irregular foldings at the base. The vertebræ were fu ossified, and may have been of the embolomerous type. The ty genus *Dendrerpeton* is a medium-sized form occurring in the C boniferous of Nova Scotia and the Permian of Bohemia, and ch acterised by the orbits being placed near the centre of the sk Another group of genera, constituting the above-mentioned Bracl pina, appears to agree so closely with the type in cranial characte that it may at least provisionally be included in the same fam The orbits are generally placed somewhat anteriorly. This gro comprises *Brachyops*, known by a single skull from the Mangli st of the Upper Gondwana system of India; *Micropholis* (*Petrophry*

[1] *Diplovertebridæ*, see note, p. 1027.

the Karoo system of South Africa; *Bothriceps*, from the Lower zoic of Australia; and *Rhinosaurus*, from the Jurassic of the Mountains. There is frequently a *lyra* on the skull, but this

962.—*a*, Oral view of palate, much reduced, *b*, Tooth, natural size, of *Baphetes planiceps*; from the Carboniferous of Nova Scotia.

anting in *Micropholis*, as in *Dendrerpeton*. It is probable that ung skeleton from the Lower Mesozoic Hawkesbury beds of South Wales, described under preoccupied name of *Platyceps*, ongs to *Bothriceps*.

FAMILY ANTHRACOSAURIDÆ.—In family the vertebral column is y ossified in the adult; the teeth deeply infolded; the mucous als between the orbits and the es form a lyre-shaped pattern own as the *lyra*; and the ventral face of the body typically has a ering of bony scutes. The skull y be parabolic, but is usually triular. This family may be divid- into three subfamilies. The first, *Baphetinæ*, is represented solely the genus *Baphetes*, of the Car- iferous of Nova Scotia, which only be provisionally placed in family. It is only known by imperfect skull (fig. 962), which broad, and rounded anteriorly.

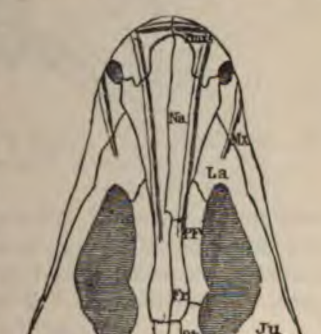


Fig. 963.—Upper view of the skull of *Loxomma Allmanni*; from the Carboniferous of Durham. Reduced. Letters as in fig. 958. (After Miall.)

the *Loxommatinæ* (*Chauliodontia*), the members of the one genus *omma* attain a large size, and are characterised by the triangular ll (fig. 963), which has large posterior projections, with the lyra ing two straight grooves, continued posteriorly as ridges. The h are compressed, large, and irregular, with the foldings deeper than in the *Archegosauridæ*. The vertebral centra are disk-like, and may perhaps be embolomerous. *Loxomma* (fig. 963) occurs in England in the Carboniferous, but has also been recorded

Fig. 964.—Dorsal surface of the skull of *Anthracosaurus Russelli*; from the Carboniferous of England. One-sixth natural size. (After Atthey.)

from the Permian of Bohemia. The large size of the orbits is well shown in the figure; another characteristic feature being the absence of a postglenoidal process to the mandible. The ventral scutes are unknown, and if it be eventually found that these are wanting, this genus should perhaps form the type of a distinct family. In the typical subfamily *Anthracosaurinæ* the skull (fig. 964) is triangular, and characterised by the small size of the palatal vacuities; while the teeth are subcylindrical. The type genus *Anthracosaurus* occurs, as its name implies, in the Carboniferous, ranging from Britain to the Continent. One of the dermal ventral scutes is shown in fig. 965. The skull was also covered with scales or scutes; and it appears from one specimen that these scutes did not extend over the parietal foramen, which induces Dr Credner to consider that the Palæozoic Labyrinthodonts were provided with a functional parietal eye, of which an aborted rudiment persists in *Sphenodon*. The imperfectly

Fig. 965.—Scute of *Anthracosaurus*. (After Atthey.)

known *Dasycœps*, from the English Permian, is allied in cranial structure to *Anthracosaurus*. Moreover, some writers place in this family the imperfectly known genera *Platyops*, from the Permian of Russia, and *Macromerion*, from the corresponding strata of Bohemia.

Family Mastodonsauridæ.—The members of this family, together with some of the *Anthracosauridæ*, constitute the Euglypta of Professor Miall's classification, and may be regarded as the typical representatives of the order. They are distinguished from the latter family by the still more complex structure of the teeth; the stronger sculpture of the skull; and the absence of scutes on the ventral surface of the body. Large palatovomerine teeth (fig. 966) are placed on the inner side of the maxillary teeth, and there is a corresponding inner series of small teeth in

Fig. 966.—Palatal aspect of the cranium of *Mastodonsaurus giganteus*; from the Keuper of Würtemberg. Reduced. (After Miall.)

Fig. 967.—*Mastodonsaurus giganteus*. *a*, Dorsal aspect of skull, greatly reduced; *b*, tooth on a larger scale.

the mandible; while there is no bony ring in the sclerotic. The following features may be also noticed, although some of them are common to the typical *Anthracosauridæ*. The mandible has a large postglenoidal process, and the crowns of the teeth are conical. The palatines have the same position as in the *Archegosauridæ*. In the pelvis of the type genus the pubes are separate from the ischia, and do not enter into the formation of the acetabulum; and the sacral ribs form kidney-like disks. The centra or bodies of the vertebræ in the adult form disks which are fully ossified; but in the young, as we infer from *Mastodonsaurus*, in which alone this has been observed, they were rhachitomous, as in the adult tion of the *Archegosauridæ*. The palatal vacuities were lar approximated, as is well shown in fig. 966. This family divided into two groups, according to the presence or abs an inner articular buttress at the proximal extremity of the ma The group in which this buttress is present is represented type genus *Mastodonsaurus*, best known by the huge *Mastodo giganteus* (figs. 966, 967) of the Trias of Europe, which p attained a length of seven or eight feet, and ranged from th chelkalk to the Rhætic. Besides other European Triassic this genus is also represented in the Lower Mesozoic (Maler of India by a form closely allied to *M. giganteus*, and by an the Hawkesbury beds of New South Wales. Figure 968 sh

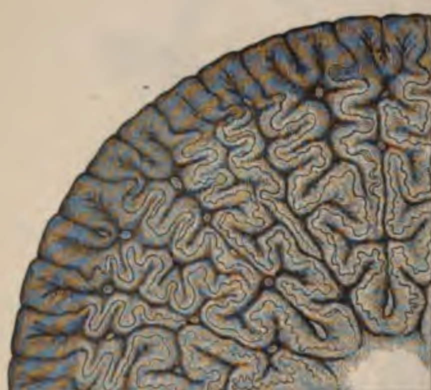


Fig. 968.—Transverse section of a segment of a tooth of *Mastodonsaurus giganteus*. Greatly enlarged. (After Owen.)

Fig. 969.— of jaw of on *Mastodonsaur* the Upper G of India. *a* section of a to

structure of a transverse section of a segment of a tooth genus; the mode of attachment of the teeth to the jaw be hibited in fig. 969. In the transverse section it will be ob that there is one set of sinuous linear interspaces commun with the exterior, and a corresponding series (separated fro other by the dental wall) of sinuous processes from the centra cavity. Other genera of this group are *Capitosaurus* (in *Cyclotosaurus*), from the Keuper of Germany; *Trematosauru* the Bunter of the same country, distinguished by its more skull; and the apparently allied *Gonioglyptus*, from the Panchet stage of the Lower Gondwanas of India. *Pachygonia* (fig. 952), of the latter deposits, may also be provisionally included in this group. From the Maleri stage of the Upper Gondwanas we have also a Labyrinthodont apparently closely allied to *Capitosaurus*, and thus indicating a precise parallelism in the evolution of the group in the Indian and European horizons. Here also we may perhaps place a small form described under the provisional name of *Glyptognathus*, from the Indian Panchets. *Metopias*, of the Continental Keuper and Rhætic, is distinguished from the preceding genera by the more anterior position of the orbits; *Labyrinthodon*, of the English Keuper, being probably allied. The second group is represented by *Diadetognathus*, of the Warwickshire Trias, in which the mandible has no inner articular buttress.

OF UNCERTAIN FAMILY.—Here may be mentioned the genus *Eosaurus*, founded upon large vertebral centra (fig. 970), from the

Fig. 970.—Two vertebral centra of *Eosaurus acadianus*; from the Carboniferous of Nova Scotia. (After Marsh.)

Carboniferous of Nova Scotia, which were regarded by Professor Marsh as belonging to an Ichthyosauroid Reptile, but which really indicate a large Labyrinthodont, perhaps referable to the *Mastodonsauridæ*.

Leaving out some ill-defined genera, mention must be made of *Pteroplax*, of the British Carboniferous, which was formerly classed next to *Batrachiderpeton*. The skull is elongated, and remarkable for the incomplete orbits; while it appears that many of the ordinary bones are wanting. The cranial bones have a pitted sculpture; and the vertebral centra are thick and fully ossified.

LABYRINTHODONT FOOTPRINTS.—In the Bunter, or Lower Tria of Germany, and also in the Keuper, or upper division of the sam

system in Cheshire and Warwickshir there are frequently found long serie of the impressions of the feet of five toed animals, which have generally been regarded as those of Labyrinthodonts although it has been suggested by Pro fessor Miall that some of them may b Dinosaurian. These footprints were described under the name of *Chirothe rium*, on the supposition that they were of Mammalian origin; but in case this should prove incorrect the alternative name *Chirosaurus* was proposed, and since they are certainly Saurian, the

Fig. 970 *bis*.—Footprints of *Chirosaurus Barthi*, from the Bunter sandstone of Hessberg, near Hildburghausen, Germany. Reduced.

latter name should be adopted. These impressions (fig. 970 *bi* were made by Saurians in which the hind foot was much larg the fore foot, some of those of the hind foot having a length ight inches. The absence of any known Dinosaurians from Bunter is strongly in favour of the Labyrinthodont nature of tracks; and it has been suggested that those described as osaurus *Barthi* were made by *Trematosaurus Brauni* of the ter, the skull of which has a length of eight inches. If this ld prove to be the case, the name *Trematosaurus* would have ield to the earlier *Chirosaurus*. The largest tracks from the per of Cheshire have been described as *C. Herculis*. Other ks of feet from the Permian and Trias, which may be of Laby-hodont origin, have been described under distinct names which ill be unnecessary to quote.

RDER II. APODA.—The remarkable limbless Cæcilians being known in a fossil state require no further mention.

ORDER III. CAUDATA.—In this order the body is elongate, and ther lacertiform or anguiform, with a tail, and usually with two, ut occasionally only one, pairs of limbs. The cranium lacks the ostorbital, supratemporal, and supraoccipital bones of the Labyrin-

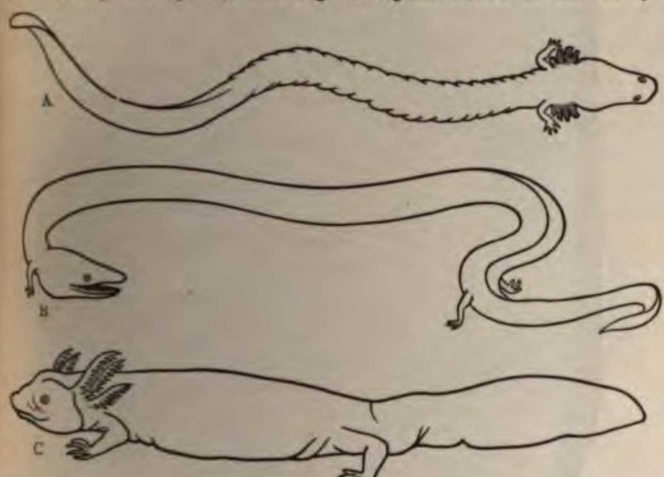


Fig. 971.—Outlines of *Siren* (A), *Amphiuma* (B), and *Menobranchus* (C). Reduced. (After Mivart.)

thodontia, and the palatines are approximated to the middle line, nd placed internally to the vomers and pterygoids. The ribs are hort, and the bodies of the vertebræ are either amphi- or opistho-celous. The resemblance in the contour of the skull and the hort ribs to the *Protritonidæ* suggests an affinity between the two oups; but the position of the palatines is rather indicative of a lationship with the *Nyraniidæ*.

FAMILY HYLÆOBATRACHIDÆ.—This family is formed

Fig. 972.—Anterior part of the skeleton of *Megalobatrachus Scheuchzeri*; from the Upper Miocene of Switzerland. Reduced.

reception of *Hylæobatrachus*, from the Wealden of Belgium, w
appears to be an ancestral form allied to the *Proteidæ*, but di

[...]ished by the presence of a maxilla, and of five digits to the [...]et.

FAMILIES SIRENIDÆ AND PROTEIDÆ.—*Siren* (fig. 971, A) and *Proteus*, together with *Menobranchus* (*ibid.*, C) are characterised by the persistent gills, the absence of maxillæ, the amphicœlous vertebræ, and the reduction of the number of the digits below five; *Siren* differing from the other two by the absence of pelvic limbs. No fossil representatives are known.

FAMILY AMPHIUMIDÆ.—In this family the gills are shed, and maxillæ are present; but it agrees with the two last in the amphicœlous vertebræ, the cartilaginous carpus and tarsus, and the absence of eyelids. In the typical North American genus *Amphiuma* (fig. 971, B) the body is much elongated, and the limbs are very short. Another American genus is *Menopoma*, allied to which is *Megalobatrachus* (*Cryptobranchus* or *Sieboldia*), typically represented by the Gigantic Salamander (*M. maximus*) of China and Japan, and in which we may probably include the large Salamander (fig. 972) from the Upper Miocene of Switzerland, originally regarded as human, and subsequently described under the name of *Andrias*.

FAMILY SALAMANDRIDÆ.—The true Salamanders lose their gills, although there are instances, as in *Amblystoma* (*Siredon*), where they persist in some individuals. Eyelids are present; the vertebræ are generally opisthocœlous; and the carpus and tarsus more or less ossified. This family is now represented in Europe by the Salamanders (*Salamandra*) and Newts (*Molge* or *Triton*). In a fossil state the existing *Molge cristata* (fig. 973) occurs in the Norfolk

Fig. 973.—The Crested Newt (*Molge cristata*).

[...]orest-bed, and representatives of this genus have also been recorded [...]om the Middle and Lower Miocene of the Continent. The latter [...]posits have also yielded remains referred to *Salamandra*, while the [...]me *Chelotriton* has been applied to an imperfectly known form from [...]e Lower Miocene of St Gérand-le-Puy, in Allier. *Heliarchon*, from [...] corresponding strata of Rott, near Bonn, is allied to *Salamandra*, [...]d may not improbably be identical with *Chelotriton*. *Megalo-*

triton is a large form from the Upper Eocene Phosphorit Central France.

ORDER IV. ECAUDATA.—The Frogs and Toads form a hi specialised order of comparatively late origin. In the adult body is short, destitute of a tail, and furnished with four limb

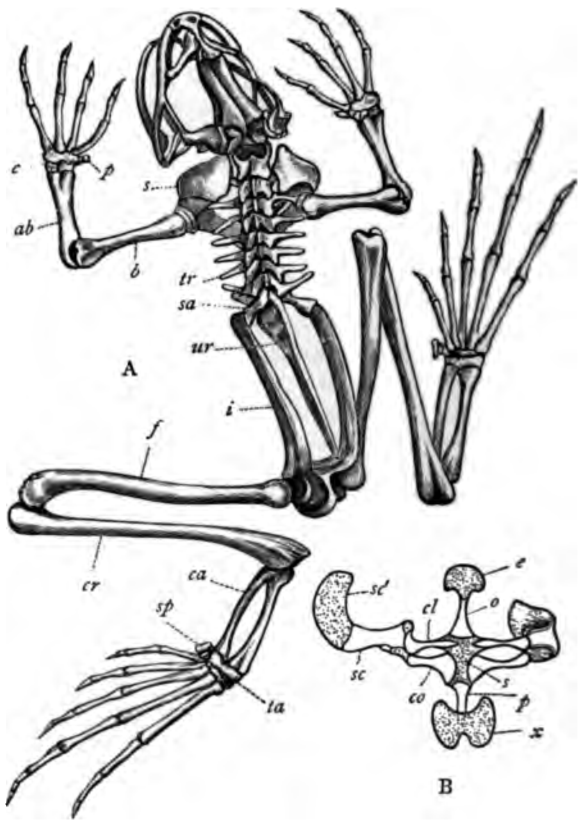


Fig. 974.—A, Skeleton of the Frog (*Rana temporaria*): *tr*, Transverse processes of ver *sa*, Sacrum; *ur*, Urostyle; *i*, Ilium; *s*, Suprascapula; *b*, Humerus; *ab*, Radius and ul Carpus; *p*, Pollex; *f*, Femur; *cr*, Tibia and fibula; *ca*, Calcaneo-astragalus; *ta*, Tars Prohallux. B, Pectoral arch and sternum of Frog (after Gegenbaur). The dotted parts re cartilages. *e*, Episternum; *o*, Omosternum; *p*, Body of the sternum; *x*, Xiphisternu Suprascapula; *sc*, Scapula; *cl*, Precoracoid; *co*, Coracoid; *s*, Epicoracoid.

which the pelvic pair is the longer, and adapted for leaping. T are no gills. The skull is short and wide, with enormous o and the parietals confluent with the frontals. A peculiar ossific known as the *girdle-bone* encircles the skull in the ethmoidal re and there is a predentary ossification in the mandible. The l vertebræ are few in number, and generally procœlous; there t one vertebra in the sacrum; the vertebral column terminates long urostyle (fig. 974, *ur*), and there are usually no separate The ilia (*i*) are prolonged backwards, so as to throw the bulum far behind the sacrum; the radius and ulna (*ab*), and ibia and fibula (*cr*) are respectively fused together; and the cal-um and astragalus (*ca*) greatly elongated. There are five digits ach foot, with an additional ossicle (*sp*) in the pes which rently represents a prohallux.

ccording to the presence or absence of the tongue this order is ded into the suborders Phaneroglossa and Aglossa; the latter aining only the two families *Dactylethridæ* and *Pipidæ*. The neroglossa are subdivided into the *Firmisternine* and *Arciferine* s; the former characterised by the epicoracoids forming a band necting the coracoids (fig. 974, B), and the latter by the over-ing of the epicoracoids. Since fossil forms are but very imper-ly known, only brief mention will be made of those families ch have fossil representatives.

AMILY DISCOGLOSSIDÆ.—Commencing with the *Arciferine* series he Phaneroglossa the present family is distinguished from those t follow, and thereby approximates to the Newts, in having opis-cœlous vertebræ and rudimentary ribs. The European genus *mbinator* is probably represented in the Upper Miocene of Swit-land; although some writers have referred the fossil species to a tinct genus under the name of *Pelophilus*. Opisthocœlous ver-bræ from the Middle Miocene of Sausan, in Gers, may belong her to *Bombinator* or to the other existing European genus *Alytes*. *ufavus*, from the Middle Tertiary of Italy, is said to present many finities to the present family, but in the absence of ribs approxi-ates to the one that follows.

FAMILY PELOBATIDÆ.—This small family is characterised by the presence of teeth in the upper jaw; the absence of ribs; and the un-expanded extremity of the sacral rib. The vertebræ are usually pro-cœlous, although occasionally opisthocœlous. The existing genus *Pelobates* occurs in the Miocene of Sausan, while the imperfectly known *Protopelobates*, from the Miocene of Bohemia, may belong either to this or the next family.

FAMILY PALÆOBATRACHIDÆ.—This extinct family has teeth in the upper jaw; no ribs; expanded ribs to the sacral vertebra; and pro-cœlous vertebræ. The single genus *Palæobatrachus* (*Probatrachus*) is now known to have been widely distributed over the Continent during the Lower Miocene; more than a dozen species having been described.

FAMILY BUFONIDÆ.—The true Toads are characterised by the otal absence of teeth and dorsal ribs; the expanded extremities of the ribs of the sacral vertebra; and the procœlous vertebræ. the type genus *Bufo* existing species occur in the European Indian Pleistocene. *B. Gessneri*, of the Upper Miocene of Sw land, appears closely allied to the living *B. viridis*, although, gether with another species from the same beds, it has been the type of *Palæophrynus*. Dr Filhol records the type genus the Upper Eocene Phosphorites of France.

Family Cystignathidæ.—This family represents the Frog Tropical America and Australia. The huge *Ceratophrys cornuta*, Horned Frog of Brazil, occurs in the cave-deposits of that coun while *Latonia*, of the Swiss Miocene, appears to be a closely if not identical genus, characterised by the smaller head, slender pelvis, shorter manus, and longer pes. A somewhat si instance of distribution occurs in the case of the Chelonian *Ch dra*. The cave-deposits of Brazil have also yielded remains of existing *Leptodactylus pentadactylus*.

Family Ranidæ.—In the *Firmisternine* series the True Fro have teeth in the upper jaw, and the extremities of the sacral are not expanded. *Rana* is represented by existing species in t Norfolk Forest-bed, and probably in the Pleistocene of Sardinia; probably also occurs in the Miocene of Sausan and other places the Continent; and has been described from the Upper Eoce Phosphorites of Central France, where the one known species see to be allied to the Indian *R. tigrina*. The Oriental genus *Oxygl sus*, in which there are no vomerine teeth, is found in the Eocene of Bombay. *Ranavus*, from the Middle Tertiary of Italy, may perhaps belong to this family, although it is said to show affinity to the *Pel batidæ*; and we may here mention the imperfectly known *Amphi rana*, *Batrachus*, and *Protophrynus* of the Lower Miocene of France, although their family position may be doubtful.

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CHAPTER LII.

CLASS REPTILIA.

General Structure.

With the Reptiles we enter upon the consideration of the first two classes which, from the possession of many common characters have been brigaded together by Professor Huxley under the name of Sauropsida. The name Monocondylia had, however, been previously proposed by Hæckel for these two classes, and some writers consequently prefer to use this term. These two classes are the Reptilia and the Aves, or Birds; and although recent research has shown the existence of a close affinity between the more generalised Reptilia and the Amphibia, and thus with the Mammalia, yet it has in no wise tended to interfere with this association. It should, however, be observed that since it is probable the Reptiles have taken origin from forms more or less nearly allied to some of the earlier Amphibia, with which we are at present acquainted, it is obvious that there must once have existed animals in which the characteristic features of the true Amphibia and the Reptilia were more or less blended, and that the practicability of drawing a distinction between the two classes is thus (as in other cases) more or less due to the imperfection of our knowledge. With this proviso, and bearing in mind that some of the more generalised forms with which we are even now acquainted may not conform in every detail with the undermentioned characters, the Reptilia as a whole, together with the Birds, may be distinguished from the preceding classes on the one hand, and from the Mammalia on the other, by the following features.

Epidermal structures in the form of scales or feathers are generally present, but there are never hairs. The vertebræ, which are ossified, usually have no epiphyses.[1] The basioccipital, with one

[1] These are present in some of the Sauropterygia among Reptiles, and in Parrots among Birds.

two exceptions, is completely ossified; and, in conjunction with the exoccipitals, forms the single occipital condyle by which the cranium articulates with the atlas vertebra. In the adult there is, as a rule, no distinct parasphenoid [1] on the base of the skull. The mandibular rami respectively consist of an articular cartilage-bone and several membrane-bones; the articular bone being connected with the squamosal of the cranium by a quadrate. The apparent ankle-joint, in all existing forms, is situated between the proximal and distal rows of the tarsus; and not, as in the Mammalia, between the tibia and astragalus. Gills are never developed during any period of life; the embryo is provided with an amnion and an allantois; and there are no mammary glands. As the palæontologist will not have to deal with the other distinctive features derived from the soft parts, it will not be necessary to refer to them in this work.

Regarding the features of Reptiles as distinct from Birds, the approximation between the two classes is so close that it is difficult to give any very clear diagnosis. In the present class, however, the epidermal structures take the form of overlapping horny scales (Squamata), or of shields with their edges in apposition (Chelonia); while dermal bony scutes are very frequently developed. The vertebræ may be amphicœlous, opisthocœlous, or procœlous; but the centra of the cervicals do not have cylindroidal and saddle-shaped articular surfaces. The sacral vertebræ, when present, have broad expanded ribs for articulation with the ilia. The sternum in existing forms is rhomboidal; and the ribs may be attached to it by a backward median process, or processes. The interclavicle is never fused with the clavicles. There are more than three digits in the manus; and never less than three in the pes. Except in the Theromorous branch, the three elements of the pelvis as a rule remain distinct; [2] and there is apparently no known instance, except one which may probably be regarded as a pathological peculiarity, of the fusion of the metatarsals, or of their union with the distal row of the tarsus. In all living Reptiles there is both a right and a left aortic arch; the arterial and venous circulations are at best but imperfectly separated; and the blood is cold.

Since the various orders of Reptiles differ so greatly from one another in structure it will be advisable to make most of our observations on their osteology under those several headings. As a rule, however, the bones of the cranium retain the general arrangement observable in the Amphibia; there being distinct postorbital or postfrontal ossifications; usually either one or two temporal arcades; and distinct post-, supra-, and infratemporal fossæ, as defined in the

[1] Dr Baur suggests that this bone may be present in *Palæohatteria*.

[2] They are anchylosed in *Testudo atlas* of the Indian Siwaliks, and also in *Miolania*.

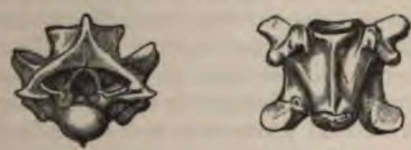
introductory chapter (p. 904). The bones of the skull are dense ivory-like structure, and in most cases their sutures pe although in certain groups the premaxillæ, frontals, and pari may respectively unite. A new element—the *transverse*, or *palatine*, bone (fig. 1089, *Ts*)—connecting the maxilla with pterygoid, appears; but this is absent in the Chelonia and Ophidia. An *epipterygoid*, or *columella*, connecting the ptery with the parietals, may also be present. A parietal foramen ma may not be present; and the occipital condyle is usually plac the hinder extremity of the cranium. The apertures of the ext nares may be terminal, as in the Amphibia, or approximated to orbits, as in the Birds; and the bones of the palate may dev a floor underlying the narial passage and thus cutting it off from mouth. As a general rule the mandibular symphysis is not chylosed; but this takes place in the Chelonia and Ornithos The quadrate may be either loosely or immovably attached to cranium.

The dentition is usually well developed, and the teeth of diffe parts of the jaws are occasionally more or less differentiated; altho there is no known instance where they are implanted by double roo or where their crowns have deep infoldings of enamel. They may present not only in the jaws, but also upon the palatine, pterygo and more rarely the vomer. In other instances, however, teeth ma be entirely wanting, and the jaws simply ensheathed in horn. Th teeth may be anchylosed to the outer side of the jaws, when th dentition is termed *pleurodont* (fig. 975); or to their summits, whe the term *acrodont* is ap plied; or they may be set in a groove, with or without anchylosis to the bone; or, finally, they may be placed in distinct sockets, whe the dentition is said to be *thecodont*. The teeth on the palate are generally anchylosed to th subjacent bones. There is usually a continuous succession of teet developed throughout life; the new teeth coming up beneath tho in use and absorbing the base of the crown, as is shown in the teet of the Gharial represented in fig. 1090. In shape the teeth Reptiles present great variation; but a very common type, fro which many of the variations are derived, consists of a more or le laterally-compressed and recurved cone, with fore-and-aft cutti edges, or *carinæ*, which may or may not be serrated (fig. 976). C casionally, however, the teeth of the jaws or those of the pala may have nearly flat crowns adapted for crushing (fig. 986).

Fig. 975.—Inner view of the left ramus of the mandible of *Iguana*.

When both pairs of limbs are present the vertebral column differentiated into cervical, dorsal, lumbar, sacral, and caudal ions; and the vertebræ themselves are ariably ossified, although in some prim-e types a small notochordal canal may rforate their centra. In a large number existing forms the majority of the centra procœlous; but they are amphicœlous many fossil and a few existing types; ile among the Dinosauria and Chelonia opisthocœlous type is common in parts the series. In all cases there is an in-rcentrum between the skull and the atlas; hich may either form the inferior ring of e latter, or, when the centrum of the atlas is separate (Ichthyoptery-a), may be of the normal wedge-like form. In some groups addi-onal articulations may be developed on the arches of the trunk verte-ræ, taking the form of a wedge-shaped process, or *zygosphene*, fitting to a corresponding cavity, or *zygantrum* (fig. 977). The transverse ocesses of the dorsal verte-ræ may be either long (fig. 958) or very short (fig. 77); and the ribs may ar-culate either by a single ead with the transverse rocess, or by two heads different portions of the ame process, or by one ar-iculation to the latter and y another to a facet on the arch or the centrum; there being great ariation as to the position of the transverse processes and rib-facets n different groups, and also in the different parts of the column of a single animal. Occasionally the ribs articulate at the junction of two vertebræ. Chevron-bones are generally present in the tail; and intercentra may be retained. No living Reptile with limbs has less than two sacral vertebræ, and in certain extinct forms the number may be increased to five or six. In nearly all Reptiles the tail is well developed. The ribs may have uncinate processes. In many existing forms the sternum, which may be ossified, is rhomboidal, and may have the last pair of ribs attached to a backward median process. Its structure in many fossil groups is not known, but according to Professor Marsh's interpretation some of the Dino-saurs had paired sternal ossifications, corresponding to the two centres from which the sternum develops in the Ratite Birds. Abdominal ribs may be developed in the parietes of the ventral

Fig. 976.—Profile and lateral views of the crown of a tooth of a Dinosaur (*Massospondylus*), with the marginal serrations magnified; from the Mesozoic of India.



A B

Fig. 977.—Posterior (A) and hæmal (B) aspects of a dorsal vertebra of a Snake. The cavities in A on the sides of the neural canal are the zygantra.

surface of the abdomen, and consist of a median and two la
moieties.

In the pectoral girdle the scapula is generally a more or elongated bone, with an expansion at its glenoidal extremity. separately ossified precoracoid exists only in the Anomodonts 978 *bis*), this bone being in other cases fused either with scapula, as in the Chelonia (fig. 1008), or with the coracoid, a Lizards (fig. 830); the fontanelle which frequently occurs in latter instances apparently marking the original line of separ of the two bones. The coracoid may vary in shape from a l spatulate form (Chelonia) to that of a cheese-cutter (Dinosauria).

The humerus has in many cases no distinct distal cond (trochleæ), although these are well developed in the Anomodo Lizards, and Sphenodon. In the more generalised types there is quently an entepicondylar foramen to this bone, but in the Liz and Chelonians the foramen or groove is ectepicondylar; and in few instances both foramina are present. The radius and ul always remain distinct. The number of bones in the carpus var considerably in the different orders, but in *Sphenodon* alone amo existing forms is there more than a single centrale; the five dis bones (carpalia) may be all distinct from one another (fig. 829). I the pelvis of the majority of reptiles, the ilium is produced mo behind than in front of the acetabulum (fig. 831), and the latter more or less completely closed by bone; while the pubis (fig. 83 is directed downwards and forwards, and, like the ischium, usuall meets its fellow in a ventral symphysis. Among the Dinosaurians however, the pelvis may be of a Bird-like type, when the pubes do not form a symphysis. Usually the obturator interval forms a open notch; but by the ventral union of the pubis and ischium o the same side this notch may be converted into a foramen. Th femur among the Dinosaurs may develop an inner trochanter; and except in some Ornithosauria, the fibula always remains distinc from the tibia. As in the carpus, the elements of the tarsus var considerably in the different groups, but the centrale (navicular) i only present in the Anomodontia, the Proterosauria (according t Professor Seeley), one family of Chelonians, and the Ichthyo pterygia; while, with the exception of a few extinct types, and perhap the existing Chelonia, the fourth and fifth tarsalia in all land form coalesce into a single bone, which supports the fourth and fif metatarsals. In certain groups—such as the Anomodontia ar many of the Chelonia (fig. 829)—the number of phalangeals in th feet of pentedactylate forms may be the same as in Mammals, 2, 3, 3, 3, 3—the digits being reckoned from the first to the fift In Lizards, however, and their allies the number of phalangeals usually 2, 3, 4, 5, 3 in the manus, and 2, 3, 4, 5, 4 in the pe the same numbers obtain in some Dinosauria; but in existing Crocodilia, in which the fifth digit of the pes is aborted, the numbers are 2, 3, 4, 4, 3 and 2, 3, 4, 4. Among the Sauropterygia and in the Ichthyopterygia the number of phalangeals is greatly increased. In a large number of forms the tail is long; but it is generally short in the Anomodontia, Sauropterygia, and Chelonia.

As regards the classification of Reptiles, scarcely any two writers agree as to the number of orders into which the class should be divided, and still less as to their mutual relations, and the larger groups under which these orders may be arranged. There is indeed but little difficulty in regard to existing forms, in which the few orders have become more or less sharply differentiated; but when we go back to the early part of the Mesozoic epoch, we find that nearly all the orders into which the class has been divided show such signs of passing more or less completely into one another, that it is quite impossible to exhibit their true relationship by any system of linear classification. The best arrangement seems, therefore, to group the orders under a series of diverging branches, which will approximate to one another more and more as we recede in time—until, about the epoch of the Lower Permian or possibly the Carboniferous, it is probable that, if we knew all the extinct forms, these branches would be seen to originate either from one, or from but very few parent stems. In regard to the number of these branches, there is still room for a considerable amount of discussion; almost the only absolutely sure ground that we can feel being the association of the three orders forming the Archosaurian branch. To a less extent the same remark applies to the orders themselves; and the right to ordinal distinction of the Proterosauria is not admitted by many writers, while there is not perfect accord in regard to that of the Rhynchocephalia. The provisional arrangement which is adopted in this work is a modification of one recently proposed by Dr G. Baur, of New Haven, and may be tabulated as follows, viz.:—

Theromorous Branch.	Order 1. Anomodontia.
Synaptosaurian "	" 2. Sauropterygia.
	" 3. Chelonia.
Streptostylic "	" 4. Ichthyopterygia.
	" 5. Proterosauria.
	" 6. Rhynchocephalia.
	" 7. Squamata.
Archosaurian "	" 8. Dinosauria.
	" 9. Crocodilia.
	" 10. Ornithosauria.

It may be added that the close approximation to the Amphibia presented by the earlier members of several of these branches suggests the idea that Reptiles may have been derived from Amphibians by more than one line of descent.

The Reptiles in the passage of time have suffered more seve than any other class of the Vertebrata, only four of the above-m tioned ordinal groups—viz., the Chelonia, Rhynchocephalia, Sq mata, and Crocodilia—now existing; and the second of these b represented only by a single genus with two species. There is so doubt as to the earliest known appearance of the class, since it been thought that *Mesosaurus* (*Stereosternum*) may be of Carb iferous age, but it is more probably Permian. In undoubted P mian we have the Proterosauria, many of the European Ano donts, and the Rhynchocephalian genus *Palæohatteria*; wh many of the American Anomodontia occur in strata which referred by the Transatlantic geologists to that period. Wi the advent of the Trias we find all the orders, with the excepti of the Ornithosauria and Squamata, more or less fully represen And while the former order makes its appearance in the succe ing Lias, we have at present no traces of the latter till the top Jurassic. The class reached, however, its zenith of developm in the Jurassic and Cretaceous epochs; the greatest num of huge aberrant forms being characteristic of the later part the former and the earlier part of the latter epoch. Although one existing Rhynchocephalian genus is closely allied to Tria forms, yet we have no instance among Reptiles of the existence a genus right up from that period to the present day, as we have i *Ceratodus* among the Pisces, thus indicating that the higher w ascend in the scale of organisation, the more rapid is the chang of types—the same law being exemplified by the occurrence of ex isting species of Reptiles among the totally extinct Mammals of the Indian Siwaliks.

CHAPTER LIII.

CLASS REPTILIA—continued.

DERS ANOMODONTIA, SAUROPTERYGIA, AND CHELONIA.

IOROUS BRANCH.—The Reptiles included in this branch ce may, for the present at least, be arranged in a single order, a some writers would prefer to regard the suborders into this order is here divided as of ordinal importance. The markable features found in this order are the resemblance on hand to the Labyrinthodont Amphibia, and on the other to notreme Mammals.

ER I. ANOMODONTIA.—This order, which is equivalent to the iora (Theromorpha) of Professor resents the following characteristic . The body is lacertiform, and bs are adapted for walking. The comparatively short, with a fixed e, a parietal foramen, either one temporal arcades, and large nasals; palate the pterygoids meet together t of the basisphenoid, which they n, but diverge anteriorly; while the s are generally small, and placed lly to the pterygoids, as in Mammals. the temporal arcade consists of only e chain of bones, it is a squamoso- ry one (p. 904). The dentition is ont, but the teeth may be anchy- o the bone. The vertebræ have œlous and in some cases noto- centra; the dorsals carrying long rse processes, and the ribs articulating by double heads in erior region of the trunk. As a rule abdominal ribs appear

Fig. 978.—The palmar aspect of the left humerus of *Ptychosiagum Murrayi*; from the Karoo system of South Africa. Half natural size. *a*, Entepicondylar foramen with the bridge broken away. (After Huxley.)

to be absent. An interclavicle, clavicles, and precoracoids a ent, and a sternum was probably always developed. The (fig. 978 *bis*) has an acromial process with which the prec articulates. The humerus (figs. 978, 982), is characterise well-developed distal condyles, and the invariable presenc entepicondylar foramen; while its delto-pectoral crest is g much developed. In the pelvis the pubis is placed ent advance of the ischium, to whi completely united, with the pres some forms of a small fontanell senting the obturator foramen. ilium may have almost its whol in advance of the acetabulum. tarsus has one centrale; and th angeals of the manus and pes a cally 2, 3, 3, 3, 3 in number Mammals, the whole structure foot being likewise of a Man type.

Fig. 978 *bis*.—Lateral aspect of the cartilage bones of the right side of the pectoral girdle of a Dicynodont; from the Karoo system of Africa. *sc*, Scapula; *a*, Acromial process of do.; *p.cor*, Precoracoid; *cor*, coracoid; *gl*, Glenoid cavity. Half natural size.

This order appears to be conf the Permian and Trias. It ha considered that the Anomodo the parent stock not only of a Reptiles (with the possible excep the Ichthyopterygia), but also Mammals. Later researches c however, altogether countenan view, although there can be nc that they are closely allied parent stock of Mammals. observations have indeed shown conclusively that this order is descended from the Labyrin Amphibians, and more especial the Archegosaurian family. Thus in the small size or absenc obturator foramen in the pelvis the entire order shows most affinities to that group; while in the small size of the cora some forms, in the presence of a distinct precoracoid (epico of very distinct condyles to the humerus, of the centrale tarsus, and also in the number of phalangeals, it has ch common both to the Labyrinthodonts and the Monotremes are not found together in any other group of Reptiles. three groups also resemble one another in the non-devel as a general rule, of abdominal ribs; while signs of affir tween them are shown by the shortness of the tail, and th of the exoccipital elements of the occipital condyle in the ent order. In the presence of an entepicondylar foramen to the ierus the Anomodonts agree with Rhynchocephalians, Sauro-ygians, and Mammals. In many cases (fig. 978 *bis*) the precora-l forms a large plate-like bone suturally united with the whole of anterior border of the coracoid, and also articulating largely with acromial process of the scapula; thus exhibiting a parallelism ween the structure of the pectoral and pelvic girdles found in no er reptiles. The above features, together with certain points in structure of the palate mentioned below, suggest very strongly descent of the Monotreme Mammals from the same primitive ck as that which gave rise to the Anomodonts. If, moreover, Dr ur is right in considering that this order does not include the ect ancestors of Mammals, it would appear that the development its more specialised representatives has followed a course in some pects parallel to that of Mammals.

SUBORDER I. PARIASAURIA.—This suborder includes the most neralised members of the order, which make the nearest approach the Amphibia. The cranium is at once characterised by the ofing over of its postero-lateral or quadratic region, after the Laby-ithodont manner, by the postorbital, squamosal, and opisthotic nes. Typically the palate, which approximates to an Amphibian pe, and has been compared to that of *Nyrania* (fig. 825), appar-tly has no flooring of the nasal passage to form secondary posterior res. The skull also has two temporal arcades, and the external rface of the cranial bones is frequently sculptured, as in the typical abyrinthodonts. The vertebral centra retain a notochordal canal; e number of sacral vertebræ was limited to two, of which only e supports the ilium; and intercentra may be present. The lvis is of a Labyrinthodont type, the ilium forming a triangular ate elongated in a direction oblique to the axis of the sacrum, ith which it articulates obliquely; and there being no obturator ramen between the pubis and ischium. The humerus probably elonging to this group differs from that of other Anomodonts in e slight expansion of the extremities, and in that the lower aperture f the entepicondylar foramen opens on the distal surface of the bone.

FAMILY PARIASAURIDÆ.—The type genus *Pariasaurus* occurs in e Beaufort beds of the Karoo system of South Africa, of which the rtebrate fauna presents a Triassic facies. The best known species P. *bombidens*) attains the dimensions of a large crocodile; and, with e unfortunate exception of the limbs, the entire skeleton is known, d has been described by Professor Seeley. In addition to the ulpture on the bones of the skull, mucous canals, like those of the abyrinthodonts, are also present. The teeth are of uniform size, d, although anchylosed to the bone, are set in distinct sockets, and were replaced after the Crocodilian manner; their crowns b somewhat compressed and grooved. The premaxillæ appe have been small, as in the Amphibia. There are 29 verte of which 18 are presacral, and two are anchylosed togethe form a sacrum; while wedge-shaped intercentra are also pre The neural spines are extremely short, and the centra of the d vertebræ are very small in proportion to their arches; and only first sacral vertebra supports the ilia of the pelvis. Small ribs present in the caudal region; and there was probably a de armour.

Professor Seeley concludes that this very remarkable and Amphib like Reptile is a direct descendant from the Labyrinthodonts; the c affinities to that group being displayed in the characters of the s in the notochordal canal, and the large arches of the vertebræ; in support of the pelvis by a single vertebra; as well as in the charac of the pectoral and pelvic girdles. The latter features, together w the general structure of the palate, being identical with those of typ Anomodonts, there appears every reason for referring this family t suborder of that group.

The genus *Propappus* is founded upon a humerus, from th Karoo system of the Cape, of the above-mentioned type, and the is no direct evidence of its distinctness from *Pariasaurus*. Th innominate bone referred to *Dicynodon leoniceps* probably belong however, to *Propappus*, which may thus be entitled to stan The pelvis and sacrum described under the name of *Dicynodo tigriceps* also seem to indicate a member of this suborder, since th ilium is of the same type as in *Pariasaurus*, and is connected wi the sacrum by only a single rib, while there is no obturato foramen.

From the general resemblance of its skull to that of *Pariasauru* we may refer to this family the genus *Anthodon*, of the Sout African Karoo system, which, although originally regarded by Sir R Owen as a Dinosaur, must be included in the present order. I agrees with *Pariasaurus* in the roofing over of the quadratic regio and the continuous replacement of the teeth, which are in a unifor series; but differs in the form of the teeth, which resemble those the Dinosaurian *Acanthopholis*.

FAMILY PARIOTICHIDÆ.—This family, although agreeing with t *Pariasauridæ* in the sculptured cranial bones and the roofing o of the quadratic region, differs in the dentition being of a car vorous type. All the known genera are from the reputed Permi of North America; and the family is included by Professor Cope the next suborder. The three genera are *Pariotichus*, *Ectocynod* and *Pantylus*. In *Ectocynodon* the first premaxillary tooth is tu like, and there is also an enlarged tooth in the middle of the ma ry series. The nostrils are large and lateral; and at the junction one of the bones of the palate with the maxilla, the tooth-bearing surface is wide, and supports four parallel rows of small obtuse teeth. *Pantylus*, which was originally described as a Labyrinthodont, the teeth are more equal in size.

SUBORDER 2. THERIODONTIA.—This suborder, which is taken (after Dr Baur) to include the Pelycosauria of Professor Cope, is characterised by the absence of a bony roof over the quadratic region of the skull, and the presence of only a single wide temporal arch (fig. 979), apparently consisting of a conjoint squamoso-maxillary and quadrato-maxillary arcade. The mandible has no lateral vacuity.

In some cases, as in the American forms, the vertebræ are still notochordal; intercentra may be developed, to which the capitular heads of the ribs are articulated, and there are not more than two or three sacral vertebræ. The dentition is fully developed. In the palate of the African forms at least the maxillæ develop palatal plates to floor the nasal passage, and thus produce tall and nearly vertical posterior nares, strikingly like those of Mammals. The premaxillæ remain separate.

In those of the typical African forms in which the pelvis is known, the ilium is somewhat intermediate between that of the Pariasauria and Dicynodontia, having a distinct but small obturator foramen. The humerus is usually more or less of a Dicynodont type, having expanded extremities, and the entepicondylar foramen with its lower aperture opening on the palmar aspect of the bone (fig. 982); there is generally a marked thin flange on the postaxial border opposite this foramen which does not occur in the Dicynodonts.

Although evidently nearly related to the Pariasauria the present group departs farther from the Labyrinthodont type, as is shown by the loss of the roofing bones in the quadratic region, as well as of the superior temporal arcade, and by the absence of sculpture or mucous canals on the skull. This advance is also indicated by the development of secondary posterior nares, by the fuller attachment of the ilia to the sacrum, and the relatively larger centra of the vertebræ of the higher types; as well as by the development of the obturator foramen in the pelvis.

FAMILY TAPINOCEPHALIDÆ.—This family may be taken to include two gigantic Anomodonts from the Karoo system of the Cape, described under the names of *Tapinocephalus* and *Titanosuchus*. The former is known typically by the extremity of the cranium; the vertebræ probably belonging to it having short and notochordal centra. A pelvis, found in association with some limb bones, has been described under the name of *Phocosaurus*, but there is no evidence to show that it does not belong to *Tapinocephalus*. T associated bones show that the coracoid was distinct from precoracoid, and that the short and massive humerus had ectepicondylar foramen. In *Titanosuchus* the dentition (as probably the case with *Tapinocephalus*) was of a carnivorous t the humerus is characterised by the presence of an ectepico foramen (in addition to the entepicondylar), which pierced through the shaft of the bone; while a bone incorrectly desc as the pubis shows that the precoracoid was fused with coracoid.

FAMILY GALESAURIDÆ.—Nearly the whole of the typical The dontia of Sir R. Owen may be provisionally included in this fa since, although genera have single others double nares skulls of the two so closely resembl another as appare render it impossibl refer them to disti families. The family characterised by th humerus (when known

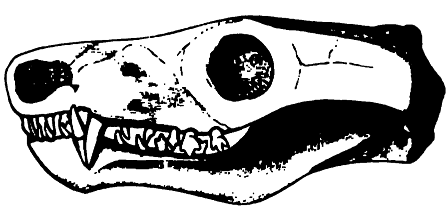
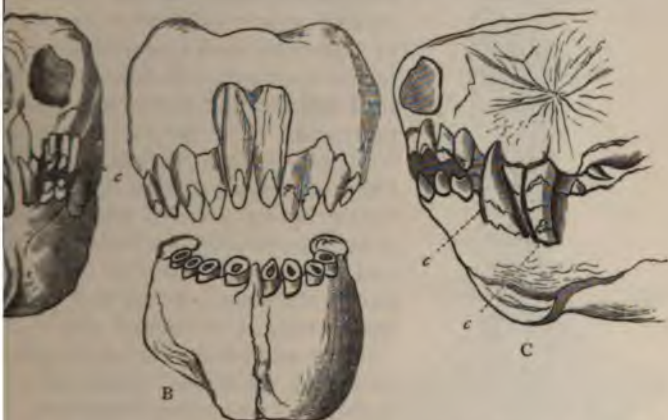


Fig 979.—Left lateral aspect of the skull of *Galesaurus planiceps*; from the Karoo system of South Africa. Reduced. *Or*, Orbit. Only some of the cheek-teeth are shown.

being of a more elongated type than in the preceding family, an by the smaller size of its members; while the vertebræ were probabl different from those of the latter, and had no intercentra. Th dentition is of a carnivorous type, and differentiated into an anterio or incisive, series separated by one large tusk or canine-like tooth from a lateral series of cheek (or molar) teeth; thus simulating th dentition of carnivorous Mammals, and more especially that of th polyprotodont Mesozoic Marsupials. There are no teeth on th palate. The majority of the genera are from the Stormberg an Beaufort beds of the Karoo system of South Africa; and we a mainly indebted for our knowledge of the group to the labou of Sir R. Owen.

In the type genus *Galesaurus*, with which *Nythosaurus* is ident cal, the skull (fig. 979) is much depressed, with the nares divide by a narrow septum; there are 4 anterior and 12 cheek-teeth, th latter having tricuspid crowns. In *Lycosaurus* (fig. 980, A, C) w have larger forms distinguished by the lateral compression of t skull, the distinctly double nares, short mandibular symphysis, a by the number of the cheek-teeth being reduced to 5; the develo ment of the tusks being very great. *Ælurosaurus*, again, appea to be a nearly allied but still more specialised genus, in which, the reduction of the septum, the nares have united to form a sin

g. *Cynodraco* (fig. 980, B) also includes large forms with developed tusks, having compressed crowns with serrated ike those of the Mammalian genus *Machærodus*; the nares livided. Other genera from the Karoo system showing the eature are *Cynochampsa*, *Cynosuchus*, and *Scaloposaurus*; the eing one of the smallest known forms. *Tigrisuchus*, again, nguished by its single nares; while *Gorgonops*, of the same s, has a narrow flattened skull, with the arrangement of the ifferent from that obtaining in all the preceding genera, and



.—A, C, Anterior and lateral views of the skull of *Lycosaurus*; B, Anterior view of the *ynodraco*; from the Karoo system of South Africa. Reduced. *c* indicates the tusk-ie) teeth. (After Owen.)

dicate a distinct family. *Deuterosaurus* and other forms e Permian of Russia, which are included by Sir R. Owen in ical Theriodontia, are noticed below.

ILY CLEPSYDROPIDÆ.—This name is applied by Professor to carnivorous Theriodontia, distinguished from the *Gale-* e either by the development of teeth on the palate, or by traordinary character of their dorsal vertebræ, in which tercentra are typically present. All the genera are typically he reputed Permian deposits of North America. In the enus *Clepsydrops* the premaxillary and maxillary teeth are qual size, and the dentary bone of the mandible has two d tusks near its extremity. Teeth are also borne on the ids; and the neural spines of the dorsal vertebræ are not vely elongated. In *Dimetrodon*, the most remarkable char- s the extraordinary development of the neural spines of the vertebræ, which resembled those of *Naosaurus* (fig. 981), with the exception of having no horizontal processes. Th of the spine in one species is more than twenty times the of the centrum; and Professor Cope concludes that these formed a kind of elevated fin on the back, of which it is to imagine the use. *Naosaurus* differs from the preceding above-mentioned horizontal proce the spines of the vertebræ (fig. The premaxilla had one tusk; an were two similarly enlarged teeth n anterior extremity of the maxilla, which comes a series of some twelv of equal size, with compressed and recurved crowns. Numerous small teeth are also dotted over the palati pterygoids. This genus has also b corded from the Permian of Bo Other American genera included family by its founder are *Embolo* *Edaphosaurus*, *Archæobelus*, *Thera* and perhaps *Lysorophus* — *Ther* being characterised by the prese well-developed abdominal ribs.

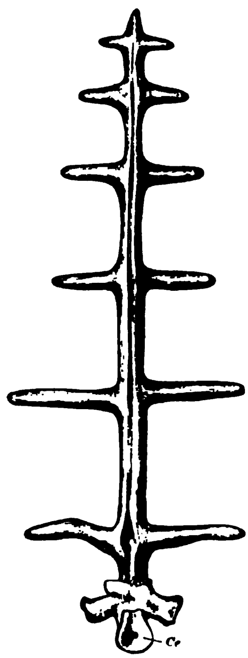


Fig. 981.—Anterior view of dorsal vertebra of *Naosaurus claviger*; from the Permian of Texas. One-sixth natural size. *Ce*, Centrum. (After Cope.)

Here may be mentioned the gen *eorhachis*, from the Lower Perm France, of which the lateral cheel tion presents a considerable resen to that of *Naosaurus*, although it known whether teeth were present palate. The neural spines of the v are of normal type; but it is not whether intercentra were present, or the centra were notochordal. The h (fig. 982) differs from that of the *C* *ridæ* in the contour of the distal ext Professor Seeley regards the above-mentioned humerus fr Karoo system of the Cape, described by him under the n *Propappus*, as indicating an allied form, but there is noth justify this association. *Stereorhachis* may constitute the ty distinct family, but there is at present no evidence to supp view that this genus (together with *Propappus*) represents a order, for which the name Gennetotheria has been proposed.

FAMILY BOLOSAURIDÆ.—This family is also typically from the reputed Permian of North America, where it is sented by the genera *Bolosaurus* and *Chilonyx*. In the the teeth are fixed in shallow alveoli, and have their crow transversely to the axis of the jaws. These crowns are at their base, and have a low apex vertically divided into tions, of which the inner one in the upper jaw is low and al, and the outer forms a curved claw-like cusp — the teeth consisting simply of an inner ledge and the outer d there being no enlarged tusks. *Metarmosaurus*, of the posits, may perhaps be referable to this family.

e large *Deuterosaurus*, from the Russian Permian, the pre-y teeth (fig. 983) approximate to the description of those *saurus*, but there are large e teeth resembling those of *lesauridæ* behind the five pre-y teeth; the nares being di- This genus may be regarded senting a distinct carnivorous A tooth from the Karoo of South Africa, having the characters of the anterior f *Deuterosaurus*, but with the borders of the inner surface crown forming ridges, has ade the type of the genus *don*. An associated series of in the British Museum may to the same form; the verte- notochordal, and the humerus in size with the one mentioned as *Brithopus*. Here may be the genus *Rhopalodon*, from mian of Russia, founded upon libular ramus which may be- the same family. Perhaps, r, the most remarkable speci- om these deposits is the distal portion of a large humerus ed under the name *Brithopus* (*Eurosaurus*); the proximal another humerus, which has received the name of *Orthopus*, ly belonging to the same species. The former specimen arkable for having both ectepicondylar and entepicondylar a—a condition elsewhere known only in *Titanosuchus* and *don*. Dr Baur has suggested that this specimen may belong hynchocephalian, but it is certain that it is referable, as Sir R. first pointed out, to the present suborder; and it is quite hat it may prove to belong to *Deuterosaurus*, in which case me should be superseded.

Fig. 982.—Anterior aspect of the imperfect left humerus of *Stereorhachis dominans*; from the Lower Permian of France. One-half natural size. (After Gaudry.)

ILY DIADECTIDÆ.—This family is also founded upon genera from the Permian of North America, and includes *Diadectes*, *pedias* (*Empedocles*), and *Helodectes*. The teeth (fig. 984) transversely elongated like those of *Bolosaurus*, and are divided by a median vertical ridge; but both the inner and outer moieties are equally low. Their alveoli are not sepa and the edges of the crowns are obtuse, with tuberosities on of them distinct from the apex of the main ridge. Professor regards this peculiar type of dentition as indicative of a herbiv diet. The brain-case differs from that of the *Clepsydropidæ* manner analogous to that in which the brain-case of the *Vara*

Fig. 983.—Lateral view of a premaxillary tooth of *Deuterosaurus biarmicus*; from the Upper Permian of Russia. Half natural size.

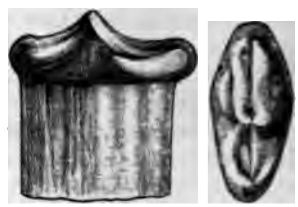


Fig. 984.—Lateral and palatal view of a posterior tooth of *Empedias molaris*; from the Permian of North America.

is distinguished from the same part in other Lacertilia—that is, it continued between the orbits so as to enclose the olfactory lob in bone. *Phanerosaurus*, from the Permian of Germany, is referr by Professor Cope, from the structure of its vertebræ, to this or t preceding family.

SUBORDER 3. DICYNODONTIA.—In this suborder the verteb have no notochordal canal; intercentra are wanting; and t sacrum includes from four to five vertebræ. There is in no ca more than one pair of teeth in the alveolar borders of t upper jaw, while there are none in those of the mandible. T palate is of the general type of that of the Theriodonts, but t premaxillæ unite to form a single beak-like bone, and the mandibul symphysis, which is very deep and laterally compressed, is likewi anchylosed. The nares are double; and it is probable that in som forms a part or the whole of the alveolar borders of the mandib was sheathed in horn; while the mandibular rami have later vacuities (fig. 985, B). There is a single temporal arcade, whi appears to be a squamoso-maxillary one. In the pelvis the ilium much expanded in an antero-posterior direction, the expanded pla ng nearly parallel to the sacrum; and there is a small obturator ramen. The humerus (fig. 978) is expanded at the two ex-emities, with a prominent deltopectoral crest,[1] and with the lower perture of the entepicondylar foramen opening on to the palmar pect. The members of this group are found in the Stormberg nd Beaufort beds of the Karoo system of South Africa, and the quivalent Gondwanas of Central India.

FAMILY DICYNODONTIDÆ.—This family is characterised by the bsence of teeth on the palate. The type genus *Dicynodon* was the first known representative of the order, and was originally described by Sir R. Owen from specimens brought from South

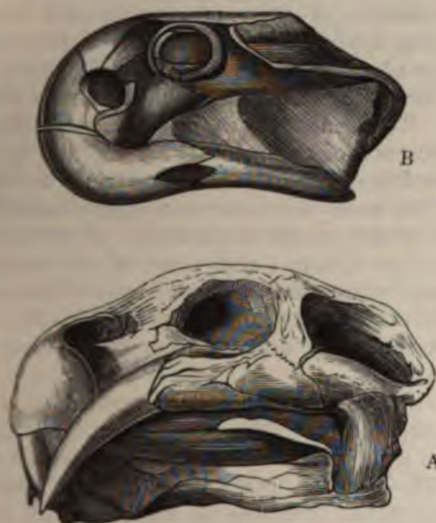


Fig. 985.—Lateral view of the skull of (A) *Dicynodon lacerticeps*, and (B) *Udenodon Baini*; from the Karoo system of South Africa. Reduced. (After Owen.)

Africa. It is characterised by the presence of a tusk-like tooth (fig. 985, A) growing from a persistent pulp in each maxilla—the rest of the jaws being edentulous, with trenchant edges. The profile of the skull is rounded, the maxillæ are not strongly ridged, the nares are approximated to the muzzle, and the supraoccipital forms a broad bar above the foramen magnum. This genus may also occur in the Panchet stage of the Indian Gondwanas. In *D. tigriceps* the skull has a length of 20 inches. In *Ptychosiagum*[2]

[1] The deltopectoral crest is the ridge on the right side of the upper half of the figure.

[2] This new name is proposed in lieu of *Ptychognathus*, which is preoccupied.

(*Ptychognathus*) there is also a pair of tusk-like upper teeth, the skull is angulated, with strong ridges on the maxilla, the far behind the muzzle, and only a very narrow supraoccipital above the foramen magnum. The typical species are from S Africa, but another representative of the genus occurs in Gondwanas of Central India, which was originally describe *Dicynodon orientalis*. A very imperfect and flattened skeleton the Karoo system has been made the type of the genus *Ci thus*, which is said to be characterised by the small size of canine-like tooth, and the presence of only two phalangeals in the digits except the third. It appears, however, that these all differences do not really exist, the difference in the humerus b due to a comparison of opposite aspects, and the number phalangeals being apparently normal, so that this form prob belongs to *Dicynodon*. The same remark will apply to part skeleton from the same beds upon which the genus *Eurycarpus* been founded. The genus *Udenodon* (*Oudenodon*) is characte by the total absence of teeth (fig. 985, B), but is otherwise closely allied to *Dicynodon* that it must certainly be included in same family. The nares are somewhat approximated to the orb and the profile of the muzzle is rounded. It occurs in the Ka system of the Cape Colony; and some of its representatives tained very large dimensions. *Cistecephalus* (*Kistecephalus*) com prises smaller forms from the same beds, in which the skull is mu depressed, with the orbits directed frontally. There was a pair tusks in the maxillæ.

The name *Platypodosaurus* has been applied to a considerabl portion of the skeleton of a Dicynodont, from the Karoo system, which the skull is unfortunately unknown, and which may prove t be identical with *Udenodon*, unless it belong to *Endothiodon*. Th remarkably Mammalian structure of the pelvis, in which there i a small obturator foramen between the pubis and the ischium, i fully noticed in Sir R. Owen's description of the specimens.

Family Endothiodontidæ.—The remarkable genus *Endothi odon*, comprising large reptiles from the Karoo system of the Cape forms the type of a family distinguished from the preceding by the presence of teeth on the palate. The skull presents a strong gen eral resemblance to that of *Udenodon*, but the muzzle is more elongated, and the nares are terminal and overhung by the massive nasals. The alveolar borders of the jaws are trenchant, but the ora surface of the palate and mandible carry one or more longitudina rows of columnar and cylindrical teeth. The remarkably Mam malian type of the palate of *Endothiodon* is noteworthy. The skul from the same deposits described as *Theriognathus* seems to belong to *Endothiodon*.

ndothiodon has been compared to the Rhynchocephalian *Rhyncho-da* and also to *Placodus;* but although there is a marked super- resemblance between the three forms in the palate and teeth, his resemblance is but apparent, since while in *Endothiodon* the are borne on a secondary bony floor beneath the narial passage, e other genera they are supported on the proper surface of the e, on which the posterior nares open directly, without the inter- ion of a secondary passage.

UBORDER 4. PROCOLOPHONIA.—According to a recent observer genus *Procolophon*, represented by comparatively small forms n the Karoo system of the Cape, differs so decidedly from the eriodontia that it is entitled to form a distinct suborder, showing rked signs of affinity with the Rhynchocephalia. The *Procolo-honidæ* have a full dentition, but no tusk-like teeth, and the nares re double. Although the pectoral girdle still has a distinct pre- racoid, yet its whole characters approximate to those of the Rhynchocephalian genus *Sphenodon*. The humerus also resembles the corresponding bone of the latter; and in the skull the pterygoids extend forwards in the same manner to join the vomers and exclude the palatines from the middle line; while there are no secondary pos- terior nares; and teeth are borne on both the pterygoids and vomers, as in the young of *Sphenodon*.

GROUP PLACODONTIA.—Our sole knowledge of this group, repre- sented by *Placodus* (fig. 986) and *Cyamodus* of the Middle Trias, or Muschelkalk of Germany, is derived from the skull, so that we are at present to a great extent in the dark as to their true affinities. These forms, after having been regarded as Ganoid Fishes, were referred by Sir R. Owen to the Sauropterygia; and the type genus resembles the Nothosaurs in the back- ward position of the nares and the form of the cranial rostrum. The skull has, indeed, been said to present many points of resemblance to that of the Anomo- donts, and more especially *Endothiodon*, to which genus it is considered by Sir R. Owen to be closely allied. The re- semblance in the form of the palate is, however, as already mentioned, only a superficial one; the present form having no floor to the narial passage, and the pos- terior nares opening directly into the roof of the mouth by horizontal apertures, as in the Sauropterygia. The skull is broad posteriorly, with double nares, a deep and apparently compound temporal

Fig. 986.—The imperfect palate of *Placodus gigas*; from the Mus- chelkalk of Bayreuth. One-fourth natural size. When entire the muzzle would form a produced rostrum.

arcade, and a postorbital bar. The palatal teeth (fig. 986) res paving-stones, and were probably adapted for crushing hard stances like the shells of Molluscs. In the upper jaw the are arranged in an outer or maxillary series of small ones, an inner or palatine series of larger ones; all being implan shallow sockets and replaced by vertical successors. In the man there is but one row of teeth. The number of palatal teeth var the different forms; and there are also modifications in the siz contour of these teeth, which aid in affording generic and sp characters. The premaxillary teeth may be of a more or prehensile type. Till the vertebræ and limb-bones are known position of these forms must remain uncertain; but it may remarked that all the known limb-bones from the Muschel except those of Dinosauria, appear to be of a Sauropterygian typ

In the typical genus *Placodus* the skull is comparatively nar and has a long rostrum produced considerably in advance of nares. The palatal teeth (fig. 986) have polygonal crowns, thos the palatine series being three in number on either side, and clo approximated; while the three premaxillary teeth are more or l chisel-like, and are separated by an interval from those on the pal The mandible has a long symphysis, and two pairs of cutting-tee The maxillary teeth may be either four or five on either si *Cyamodus* is readily distinguished by the great width and short of the cranium, which has no distinct rostrum, with the nares plac at the muzzle and the premaxillæ fused together. The palatal tee have rounded crowns, the crown of the last palatine being ve large; there may be either two palatine and three maxillary, or tw maxillary and three palatine teeth. There were but two pairs premaxillary teeth, which are not chisel-like. In the lower jaw th symphysis was triangular and comparatively short, and was probabl devoid of teeth.

Recently Dr Gürich has proposed the name *Pleurodus* for a allied form from the Muschelkalk of Silesia, but since this term i preoccupied for a Crocodilian genus it will have to be changed.

SYNAPTOSAURIAN BRANCH.—According to Dr Baur's scheme classification this branch comprises the orders Sauropterygia an Chelonia; although Professor Cope and Mr Boulenger would al include the Rhynchocephalia. The typical Proganosauria of Baur may be merged in the Sauropterygia. Although the Saur pterygia and Chelonia present many characters in common, yet it not easy to give a definition of this branch. In all, however, t quadrate is firmly united to the skull; and all, or nearly all, of t dorsal ribs articulate with the vertebræ by single heads. As a gen ral rule the palate is more or less completely closed, the pterygo generally extending forwards to join the vomers. There may either one or two temporal arcades. A parietal foramen is present at least in the young. In all cases ossifications are developed upon the ventral aspect of the body, either in the form of abdominal ribs, or of a plastron; but there are none in the sclerotic of the eye. The sacral ribs are connected with the vertebræ by upper and lower articulations; and when chevrons are present they are mainly or exclusively attached to the hinder borders of the caudal centra. A precoracoid anchylosing to the scapula may be present in the pectoral girdle; and in the pelvis the pubis and ischium have expanded and flattened ventral surfaces, and the obturator foramen may be completed by the union of the ischium with the pubis of the same side. There is, moreover, a considerable structural resemblance between the limb-bones of the more generalised forms of the two orders, these bones always having terminal epiphyses; and the tarsus in both may be of a very primitive type. The humerus may have either an entepicondylar (ulnar) foramen and an ectepicondylar (radial) groove, or only the latter, or may be devoid of both. The ribs never have uncinate processes.

We are still very much in the dark as to the origin of these two orders, although the Sauropterygia can be traced back to a form presenting several Amphibian features, which appears to have been closely allied to the primitive Rhynchocephalians. From the disappearance of numerous segments in the vertebral column of the Chelonia during development, Professor Parker has suggested that this order has originated from a type allied to the Sauropterygia; and their plastron is almost certainly derived from, or developed upon, the abdominal ribs of a form allied either to the Rhynchocephalia or to *Mesosaurus*.

ORDER II. SAUROPTERYGIA.—In this extinct order the body was devoid of any exoskeleton, while the neck was more or less elongated, and the tail short. In the skull there is only the superior temporal arcade; the narial apertures are lateral and more or less approximated to the orbits; the premaxillæ are very large; and there is a well-developed parietal foramen in the adult. The prefrontal remains distinct; the postorbital may be separate from the postfrontal; typically there is a transverse bone; and the symphysis of the mandible is united by suture. The teeth, which are implanted in distinct sockets and confined to the margins of the jaws,[1] have curved sharp crowns, with fluted enamel. Each rib articulates to a single vertebra, and in the cervical region the costal facets, which may be either single or double, are situated entirely on the centrum, and generally are not prominent. The vertebræ are amphicœlous; and the neuro-central suture may be either persistent throughout

[1] Assuming that the Placodontia are distinct from this order.

life, or completely obliterated. All those vertebræ in whic costal articulation is on the centrum below the neuro-central may be reckoned as cervical; their number varying from abo to nearly 40. The centrum of the atlas is well developed, and is a wedge-shaped intercentrum between the latter and the The true cervicals are succeeded by a few vertebræ in whic costal articulation is partly on the arch and partly on the cer for which the name of pectorals has been proposed. The vertebræ have the costal articulation placed entirely on the and generally forming an elongated transverse process. The vertebræ are always furnished with true ribs, and also with ch bones, which may not be united below. The structure of the toral girdle is very remarkable, and has given rise to consid diversity of opinion. In all forms the coracoids meet in a m symphysis, which may be short (fig. 987) or very long (fig.

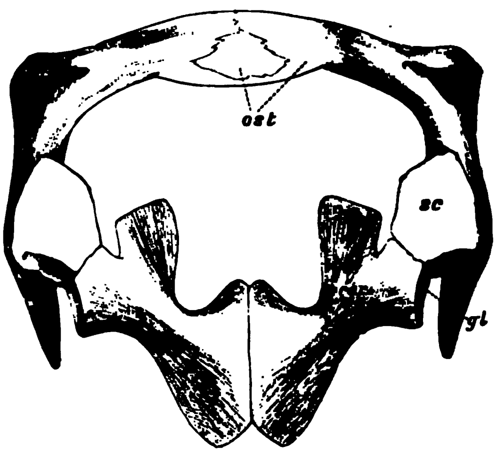


Fig. 987.—Ventral aspect of the pectoral girdle of *Nothosaurus mirabilis*; from the kalk of Würtemberg. Reduced. *ost*, Clavicle and interclavicles; *sc*, Scapula; *gl*, cavity; *cor*, Coracoid.

In the generalised *Nothosaurus* (fig. 987) the scapula has small ventral portion, separated by a wide interval from that fellow. Anteriorly to these ventral plates of the scapulæ is a slender arch consisting of a median and two latera tions, corresponding to a similarly situated bone in *saurus*. This arch is usually correlated with the interclavicl clavicles; but from the deep-seated position of its represe in *Plesiosaurus*, Mr Hulke considers that in that genus it sponds to the omosternum of the Amphibia, and if this in be correct, it will have the same homology in *Nothosaurus*.[1] ecialisation proceeds it appears that the scapulæ have tended elop very large ventral plates, with a concomitant reduction ltimate disappearance of the clavicular arch. The inter- e stage is shown in *Plesiosaurus* (fig. 997), where it will n that the ventral plates of the scapulæ are separated in dian line; and the culmination in *Cimoliosaurus*, where they n a median symphysis, and join the anterior extremities of oracoids, while the avicle has disap- . Mr Hulke regards entral plate of the a as representing the acoid of the Chelo- ut further evidence uired to prove this; w that it represents vicle being obviously ect. In the pelvis ibis usually forms a plate, while the isch- somewhat chopper- l; in some cases the and ischium of each nite to enclose an tor foramen. The are strikingly like of the Amphibia, and a long symphysis. imbs are subject to derable variation;

Fig. 988.—Ventral aspect of the pectoral girdle of *Cimoliosaurus* (*cf*) *trochanterius*; from the Kimeridge Clay. Reduced. *sc*, Scapula; *pc*, Ventral (precoracoidal) plate of do.; *gl*, Glenoid cavity; *f*, Scapular foramen; *co*, Coracoid. (After Hulke.)

of the earlier generalised forms being adapted for progres- on land, while in the specialised types they are modified addles. In all cases, however, the limbs are readily distin- d from those of the Ichthyopterygia by the relatively longer us and femur, and the absence of interdigital bones. The ones are regarded by Professor Seeley as showing signs of ibian affinity. A peculiar feature in the limb-bones is that iphyses (fig. 989) of the humerus and femur are enormously ped, and form large cones at either extremity of the bones, , or completely, meeting in the middle of the shaft, which uced to a pair of elongated cups. The bones of the palate

he British Museum Catalogue of Fossil Reptilia Mr Hulke's interpreta- the homology of these bones was provisionally adopted, but the writer nsiders that the other interpretation is probably the true one.

never develop plates to form a floor to the nasal passage, so the posterior nares also open directly into the mouth by hori apertures (fig. 991).

This order ranges in time probably from the Permian and tainly from the Trias to the Upper Chalk, and we are enabl trace the gradual evolution of the specialised marine forms those less widely separated from a normal type. All these re appear to have been carnivorous.

FAMILY MESOSAURIDÆ—The genus *Mesosaurus*, originally scribed from the Karoo system of Griqualand in South Af which is probably of lower Mesozoic age, but subsequently fo in beds of uncertain age in Brazil, and described under the n of *Stereosternum*, includes small reptiles regarded by Dr Baur

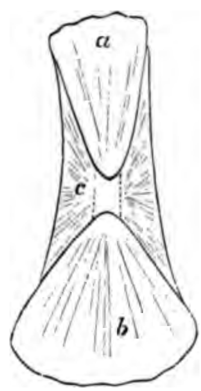


FIG. 989.—Longitudinal section of a Sauropterygian humerus; from the Kimeridge Clay; one-sixth natural size. *a*, Proximal, *b*, Distal epiphysis; *c*, Shaft.

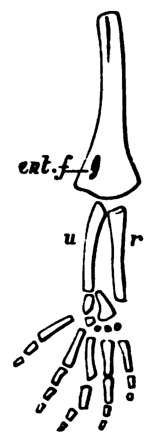


FIG. 990.—Ventral aspect of the left pectoral limb of *Mesosaurus tenuidens*; from the Karoo system of Griqualand. *ent.f*, Entepicondylar foramen of humerus; *r*, Radius; *u*, Ulna.

constituting a distinct order — the Proganosauria, — but wh appear to be so closely related to the *Nothosauridæ*, that there be little, if any, hesitation in including them in the same or The Brazilian form was originally referred with some hesitation Professor Cope to the Amphibia. One of the most peculiar f ures of this genus, in which it differs from all other groups exc the Amphibia, the extinct *Palæohatteria*,[1] and perhaps the Chelc is the separation of the fourth and fifth tarsalia, so that each m tarsal articulates with a distinct tarsale. The centra of the verte

[1] See Rhynchocephalia, *infra*.

have a small notochordal canal, and are small in comparison to the neural arches; while the ribs seem to have been anchylosed to the vertebræ, and were of great thickness, like those of the next family. The system of abdominal ribs was strongly developed. The skull is much elongated, and has slender recurved teeth, which were in all probability implanted in distinct alveoli. The pectoral girdle appears to be very similar to that of the *Nothosauridæ*, the presumed interclavicle not being T-shaped; and a similar close resemblance is presented by the pectoral limb (fig. 990), in which the humerus has an entepicondylar, or ulnar, foramen, like that of Mammals. The pelvis is considered to have had only a very small obturator foramen; the ischia and pubes forming broad expanded plates like those of Amphibia and other Sauropterygia. The terminal digits were devoid of claws; and the feet were probably webbed like those of frogs.

Dr Baur makes this genus the type of the order Proganosauria, in which he would also include the undermentioned genus *Palæohatteria*; and regards this order as the connecting-link between Amphibians and Reptiles. Although there is something to be said in favour of this view, yet the manifest affinity of *Mesosaurus* to the more typical Sauropterygia, and of *Palæohatteria* to the Rhyncho-

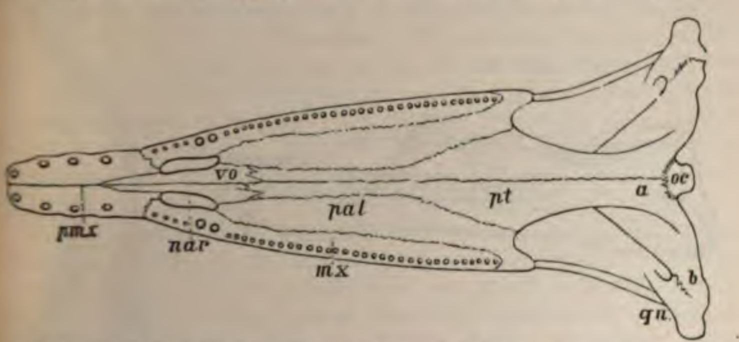


Fig. 991.—Palatal aspect of the cranium of *Nothosaurus mirabilis*; from the Muschelkalk. One-eighth natural size. *pmx*, Premaxilla; *nar*, Posterior nares; *vo*, Vomer; *mx*, Maxilla; *pal*, Palatine; *pt*, Pterygoid; *a*, Ala of do.; *b*, Quadratic ridge of same; *qu*, Quadrate; *oc*, Occipital condyle. The posterior extremity of *pal* is probably formed by a distinct transverse bone.

cephalia, seem to render it more advisable to refer those genera to the two orders in question, of which they will respectively form the most generalised stage. By this arrangement the intimate connection of both orders with the Amphibia will be made manifest.

Family Nothosauridæ.—In this family, which comprises some forms of large size, the limbs were furnished with claws, and adapted to a certain extent for walking. In the skull the pterygoids either diverged posteriorly, or gave off wings uniting in the middle upon the basi- and presphenoid, and thus completely closing posterior portion of the palate (fig. 991)—an approximation latter arrangement occurring in some Chelonia. The palate also devoid of infraorbital vacuities. The coracoids (fig. 987) a short median symphysis, not extending as far forwards as scapular articulation, and also had a groove; while the ve plates of the scapulæ were very small. Typically, the cer vertebræ have double costal facets, while the transverse proc of the dorsals are very short, and remarkable for the vertical elo tion of their articular faces. The humerus and femur are elong —the former (fig. 993) having an entepicondylar foramen, bu distinct distal expansion. The ischium and pubis did not unit enclose an obturator foramen.

The known forms occur typically in the Muschelkalk, or Mid Trias, of the Continent, but some of them range up into overlying Keuper, and one species is found in the Bunter, Lower Trias. In the typical genus *Nothosaurus* the skull (f 991, 992) is long and much depressed, the length of the po orbital exceeding that of the preorbital portion. The charact

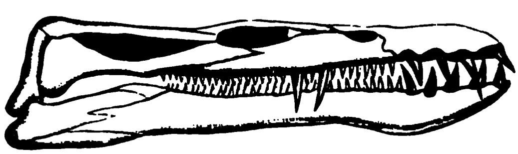


Fig. 992.—Right lateral aspect of the skull of *Nothosaurus mirabilis*. Reduced. (After Meyer.)

Fig. 993.—Ventral aspect of the right humerus of *Conchiosaurus*. One-half natural size. *Ent.f*, Entepicondylar foramen; *a*, Ectepicondylar groove.

of the palate are shown in fig. 991. *Conchiosaurus* is a closely allied but smaller form, in which the teeth are club-shaped. In *Simosaurus* the skull is characterised by the breadth of the facial portion and its stout teeth. The type species is nearly equal in dimensions to the larger species of *Nothosaurus*. Finally, *Pisto-*

rus is distinguished by the posterior divergence of the pterygoids, not improbably by the presence of long transverse processes to dorsal vertebræ; both of these features being Plesiosaurian. e preorbital portion of the skull is very narrow. Although the mbers of this family have lost all traces of a notochordal canal the centra of the vertebræ, yet the ossification of these centra as taken place in the same manner by means of a sheath investing he notochord.

FAMILY LARIOSAURIDÆ.—This family is closely allied to the preceding, but the limbs approximate to those of the *Plesiosauridæ*. The skull, at least in one genus, has infraorbital vacuities on the palate, and the coracoid has no notch at its glenoidal extremity. The femur always remains an elongated bone, longer than the epipodials and metapodials collectively; but the humerus may be comparatively short, and is more or less expanded at its distal extremity; while in *Lariosaurus*, although not in the other forms, it has lost its foramen. The terminal phalangeals of the pes still retain their claws. In *Neusticosaurus* it is thought that cervical ribs were wanting. The type genus *Lariosaurus* comprises one medium-sized species from the Trias of Lombardy, and according to Dr Baur, has both limbs adapted for walking. The palate is unknown. In *Neusticosaurus*, from the Lettenkohle at the base of the Keuper of Würtemberg, Professor Seeley considers that the pectoral limb had become modified into a paddle, although this conclusion is not accepted by Dr Baur. It appears probable that a small reptile, described from the Trias of Italy under the preoccupied name of *Pachypleura*, is not more than specifically separable from *Neusticosaurus*. The type species of the latter was about one foot in length, and was probably of amphibious habits.

It may be convenient to notice here two small Triassic reptiles which are referred by Dr Baur to this family, although Dr Deecke considers that at least the second has more affinity with the Lizards. These genera are *Dactylosaurus*, from the Muschelkalk of Silesia, and *Macromerosaurus*, from the Italian Trias; the former being almost certainly referable to this order, and perhaps not separable from *Neusticosaurus*. In this connection it should be observed that Dr Bassani considers *Macromerosaurus* to be identical with the type species of *Lariosaurus*, and that *Neusticosaurus* is not generically separable from the latter. *Pachypleura* is, however, regarded as distinct from *Neusticosaurus*, in which case it will require a new name, as the present one is preoccupied.

Finally, it should also be mentioned that some authorities would regard the two preceding families as constituting a distinct suborder—the Nothosauria—but the transition to the next family is almost complete.

Family Plesiosauridæ.—With this group we come to the c sideration of the typical members of the order, all of which adapted for a purely aquatic life, and probably frequented co and estuaries. In the skull the pterygoids verge posteriorly, and do not overlie the sphenoid; while there were small infraor vacuities in the palate. The dorsal verte have long transverse processes. In the pecto girdle the scapulæ have large ventral pla which may meet in the middle line; and symphysis of the coracoids is much elong and extends in advance of the scapular artic tion. In the limbs (fig. 994) the humerus femur were comparatively short and distally e panded; the former being devoid of a foram The bones of the second segment are likewi very short, and strangely altered from the norm form. In certain cases, moreover, a third bon (fig. 998) articulates with the humerus an femur, of which the homology will be discusse under the head of the Ichthyopterygia. Th metacarpals and phalangeals are, however, stil elongated, but the number of the latter is in creased beyond the normal complement. Further, the termin claws have disappeared; and the whole limbs were doubtless en veloped in a common integument, to form paddles after the fashio of the turtles. The coracoid (fig. 988) is remarkable for its grea

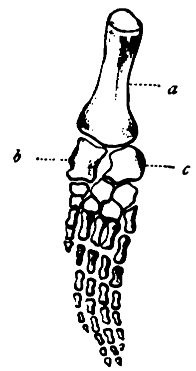


Fig. 994.—Dorsal aspect of the left pectoral limb of *Plesiosaurus Hawkinsi*; from the Lower Lias of Dorsetshire. Reduced. *a*, Humerus; *b*, Radius; *c*, Ulna.

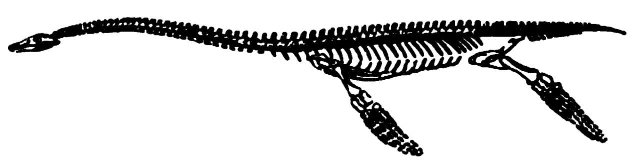


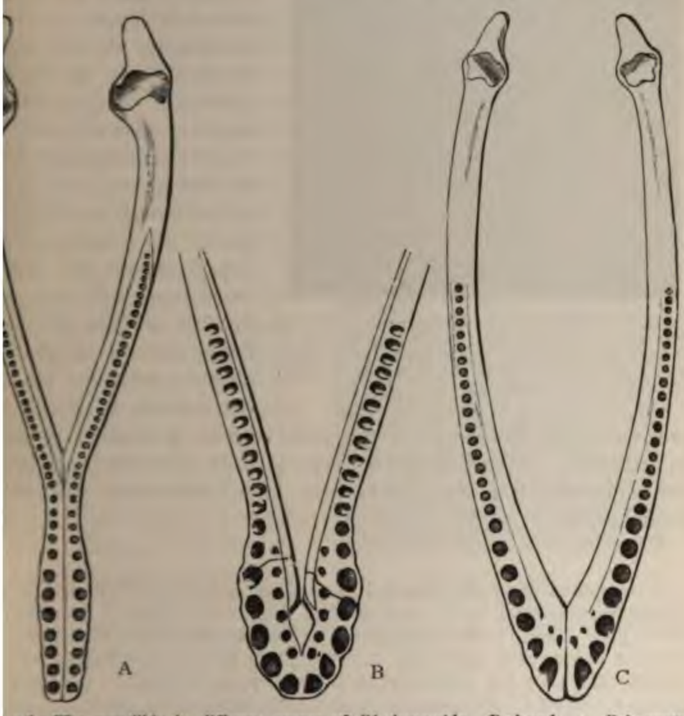
Fig. 995.—Skeleton of *Plesiosaurus dolichodirus*; from the Lower Lias. Greatly reduced. (After Conybeare.)

antero-posterior length, and has no fontanelle. This family includ some forms of huge dimensions; its range extending from t Rhætic, or Uppermost Trias, to the Chalk.

The *Plesiosauridæ*, like the Crocodiles of the present day, dif greatly among themselves in the relative length of the mandibu symphysis, as is shown in the accompanying woodcut. In t present family it appears, however, that the result of evolution a specialisation has been towards the gradual lengthening of this sy

; whereas among the Crocodilia the tendency has been pre- in the opposite direction.

is family has been divided into a large number of genera, but several of these are not really distinct it will suffice to adopt a er number of such divisions. The genus *Plesiosaurus*, as now ted, is exclusively confined to the Upper Trias (Rhætic) and Owing to the beautiful preservation of many of the species



996.—The mandible in different genera of *Plesiosauridæ*. Reduced. A, *Peloneustes* *rhus*, from the Oxford Clay, one-eighth natural size; B, *Thaumatosaurus indicus*, from pper Jurassic of India, one-seventh natural size; C, *Plesiosaurus dolichodirus*, two-fifths l size.

genus has been long known to science; and its remains were irably described in the first third of the present century by the Mr Conybeare and Dean Buckland, who with remarkable fore- hinted at the affinity of these strange and weird forms of Rep- life to the Chelonia. In this genus the skull is either small a short mandibular symphysis (as in fig. 996, C), or moderately with a longer symphysis and rostrum. The teeth are generally ler, without carinæ, and the terminal ones are not much larger

than the others in the more typical species. The neck is m
less elongated, with the anterior vertebræ in most cases very

Fig. 997.—Ventral aspect of the pectoral girdle of *Plesiosaurus dolichodirus*; from the Lower Lias of Dorsetshire. Reduced. *ost*, Interclavicle; *sc*, Scapula; *pc*, Ventral plate of do.; *co*, Coracoid; *H*, Head of humerus. (After Hulke.)

The cervical ribs an
ral arches are firmly
lated to the centra
vertebræ, but traces
suture usually persist;
cervical region the fac
the articulation of th
are usually double, a
terminal faces of the
generally ellipsoidal,
more or less cupped.
most characteristic fe
of the genus are, ho
to be found in the p
girdle (fig. 997), in
the scapulæ are rel
small, and widely sep
in the middle line,
they rest upon the
clavicle, with its sma
deep notch. The cor
are, moreover, long and rather narrow, with a median prod
in advance of the glenoid cavity; while the foramen be
the coracoid and scapula is very large and open toward
interclavicle.

This genus may be divided into three groups. The *Longir*
group, represented by *P. rostratus* of the Lower and *P. longiros*
the Upper Lias, is characterised by the comparatively elongated
dibular symphysis, and the extremely short neural spines and
costal facets of the majority of the cervical vertebræ. In the
group we have *P. dolichodirus* with its extremely long neck (fig. 99
shorter-necked *P. Hawkinsi*, and the large *P. Conybeari*, all bein
the Lower Lias. These forms have a moderately short mandibula
physis (fig. 996, C), while the centra of the cervical vertebræ are
greatly elongated, and there are double costal facets and moderat
neural spines in this part of the vertebral column. The third g
represented only by *P. homalospondylus*, of the Upper Lias, w
characterised by the great elongation of the centra of the cervic
tebræ, which have flat terminal faces, and enormously tall neural
The resemblance of these vertebræ to those of the cervicals of the
group of the Jurassic and Cretaceous genus *Cimoliosaurus* sugge
origin of the latter group from the present; whereas on similar g
it may be suggested that the *Cœlospondyline* group of *Cimoliosaur*
originated from the typical group of *Plesiosaurus*. In all species
present genus the radius and ulna (fig. 994) still retain evidence c

l character as long bones, and are separated by a well-marked
.

ther exclusively Liassic and perhaps Rhætic genus is *Eret-*
us, which had a long neck and probably a small head like
aurus, but with a very different type of pectoral girdle. Thus
acoids had no median production in advance of the glenoid
while the scapulæ were large, and articulated together in the
line, and posteriorly were united by their whole length with
acoids, leaving only very minute coracoidal foramina. If an
avicle were present it had
e fused with the scapulæ.
ype species is from the
Lias, but there is another
Upper Lias. The largest
of the family is, however,
osaurus, in which we may
iently include those forms
ed under the names of
aurus, *Elasmosaurus*, *Mau-*
s, *Polycotylus*, *Muræenosau-*
nd *Colymbosaurus*. This
was originally described
the evidence of a very
pecies from the Cretaceous
w Jersey, with which *Dis-*
us, and probably *Elasmo-*
, are specifically identical.
New Zealand Cretaceous
s described as *Mauisaurus*
ely allied; and it has yet
roved that the type species
n specifically distinct from
ropean *C. constrictus*. Many of the other species differ con-
bly from these typical forms, but if generic divisions are once
it seems impossible to know when to stop.

Fig. 998. — Ventral aspect of the right humerus, radius (*T*), ulna (*i*), and pisiform (*F*) of *Cimoliosaurus trochanterius*; from the Kimeridge Clay of Dorsetshire. Reduced. (After Hulke.)

genus in the above extended series may be characterised as
. The teeth and skull are relatively small, the mandibular
ysis is short, and the neck usually very long, with the anterior
æ relatively small. The vertebræ are more or less elongated,
nerally have the neural arches and the cervical ribs completely
osed to the centra in the adult; the costal articulations always
g single facets in the cervical region. In the pectoral girdle
8) the scapulæ have very large and wide ventral plates, meeting
middle line, without any trace of an interclavicle, and usually
g down a median process to join the coracoids, and thus com-

pletely closing the scapulo-coracoidal foramen.[1] The hume 998) is usually longer than the femur; and both these eleme articulate distally with either two or three (figs. 998, 999, bones, which in the later instances lose all resemblance to mal elongated form. The ischia are relatively short.

This genus may be divided into two groups, according to whe vertebral centra have nearly flat or deeply cupped centra. In th group we have the large *C. truncatus* of the Kimeridge, and the *C. plicatus* (fig. 1000 *bis*) and *C. Richardsoni* (fig. 1000) of the Oxfo in both of which the humerus articulates only with the radius an the latter species being distinguished by its shorter cervical v

Fig. 999.—Ventral aspect of part of the right pelvic limb of *Cimoliosaurus portlandicus*; from the Portland Oolite. Reduced. *T*, Preaxial; *F*, Postaxial border; 66, Tibia; 67, Fibula; 67', Homologue of the pisiform; *t*, Tibiale; *c* 1, Intermedium; *c* 2, Fibulare; *f*, Postaxial tarsal. (After Hulke.)

Fig. 1000. —Ve pect of part of pectoral limb of *saurus Richards* the Oxford Clay eighth natural Humerus; *tr*, T of do.; *r*, Radius; *r'*, Radiale; *i*, dium; *u'*, Ulnare. Mansel-Pleydell.)

In *C. portlandicus*, of the Portland Oolite and Purbeck, the three short bones articulating with the humerus and femur (fig. 9 is in the Cretaceous, however, that we meet with the largest rep tives of this group, which comprise *C. constrictus*, of the Europea and Chalk; *C. vetustus* and *C. platyurus*, of the Cretaceous o America; and *C. Haasti*, in the corresponding strata of New Z These were enormous reptiles, with an estimated length of bet

[1] Occasionally, as in *C. durobrivensis*, of the Oxford Clay, this bar absent, but it is not known whether this is only an individual peculiarity.

40 feet, and having nearly 40 cervical vertebræ. In the second p, which apparently corresponds to the genus *Polycotylus* of Pror Cope, we have, in the Oxford Clay, *C. oxoniensis* and *C. eurymerus*, hich the humerus articulates with only the radius and ulna, and in

1 2 3

. 1000 *bis*.—A cervical vertebra of *Cimoliosaurus plicatus*; from the Oxford Clay. One-fifth natural size. 1, Posterior; 2, Inferior; 3, Anterior aspect. (After Phillips.)

Kimeridge the larger *C. trochanterius*, in which the pisiform also joins humerus (fig. 998). The very small *C. valdensis*, of the Wealden, may been of freshwater habits; while in the Chalk we find the larger *C. nkardi*. This group appears to have been also represented in the aceous of North America and New Zealand. A species from the aceous of Kansas, described under the name *Trinacromeron*, has three bones articulating the humerus.

Fig. 1001.—Dorsal aspect of part of the left pelvic limb of *Peloneustes philarchus*; from the Oxford Clay. One-sixth natural size. *fe*, Distal half of femur; *t*, Tibia; *f*, Fibula; *t'*, Tibiale; *i*, Intermedium; *f'*, Fibulare. The tibia is drawn rather too small in proportion to the fibula.

he imperfectly known genus *Polyptychodon thesaurus*), of the Middle and Upper Creous of Europe, appears to be allied to *oliosaurus*, but with a relatively larger d and teeth, and probably with a much rter neck. The teeth, which are very ndant in the Cambridge Greensand, have conical crowns, with strongly-marked es, of which a considerable number geney stop short of the summit. These Rep must have attained huge dimensions. genera we have now to consider indicate fferent branch from that to which the two eding genera belong. The first of these *Thaumatosaurus* (in which *Rhomaleosaurus* be included), typically occurring in the at Oolite of Würtemberg, but extending nwards to the Lower Lias and upwards he Kimeridge Clay of England. In these s the skull and teeth were relatively large, the latter being carinated, and the mandibular symphysis (fig. 996, B) comtively short, with the first five or six teeth enlarged. The neck was short, and the cervical vertebræ have comparatively short distinctly cupped subcylindrical centra, carrying double facets; while the arches and cervical ribs were firmly articulat the centra. In the pectoral girdle the scapulæ and coracoids of the general type of those of *Plesiosaurus;* but the clav

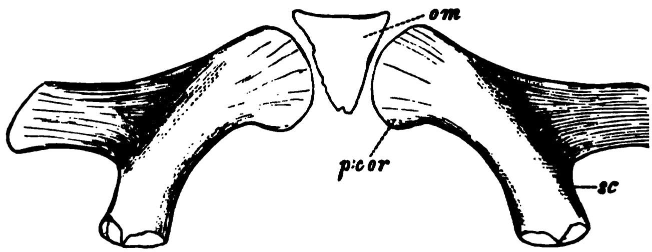


Fig. 1002.—Anterior part of the pectoral girdle of *Peloneustes philarchus;* from th Clay. Reduced. *om*, Interclavicle; *sc*, Scapula; *p.cor*, Ventral plate of do. The aspect is shown.

arch was greatly elongated transversely, and was probably lapped by the scapulæ. The humerus was longer or shorte the femur, and articulated only with the radius and ulna, were considerably elongated, and separated by a distinct int This genus is represented in the Lower Lias by *T. megace* and *T. arcuatus*, and in the Upper Lias by the gigantic *T. C toni*, which attained a length of some twenty The type species, only known by detached and vertebræ, occurs in the Great Oolite o Continent; while *T. indicus* (fig. 996, B) is in the Upper Jurassic of India.

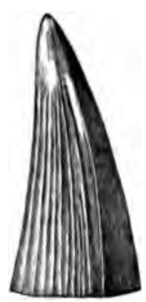


Fig. 1003.—Crown of a tooth of *Pliosaurus brachydirus;* from the Kimeridge Clay of Ely. One-half natural size.

In the genus *Peloneustes*, of the Oxford Kimeridge Clays, the coracoids (fig. 1001) d appear to have been produced anteriorly i middle line; while the scapulæ have their v surface broad and flat, and the dorsal surfa duced (fig. 1002). The same figure also show extremely small size of the interclavicle. The were very long. The mandibular symphysis 996, C) is greatly elongated; but the vertebræ with those of *Thaumatosaurus* in the firm a ment of the arches and cervical ribs to the c although the centra themselves have the terminal faces f and with a transversely elliptical and somewhat angulated co The radius and ulna are nearly as broad as long, and have a very small interval between them. The most specialised of this branch is *Pliosaurus* (*Ischyrodon*, *Spondylosaurus* or *leurodon*), which thus occupies a somewhat similar position to the one held by *Polyptychodon* in the preceding branch. This genus is represented by several species of gigantic Reptiles ranging from the Oxford to the Kimeridge Clay, but of which derived remains are also found in the Lower Greensand of Potton, in Bedfordshire. The skull and teeth (fig. 1003) are relatively very large; the former having a somewhat shorter mandibular symphysis than in *Peloneustes*. The teeth are carinated, and in the Kimeridgian species the space between the two carinæ is nearly flat, and

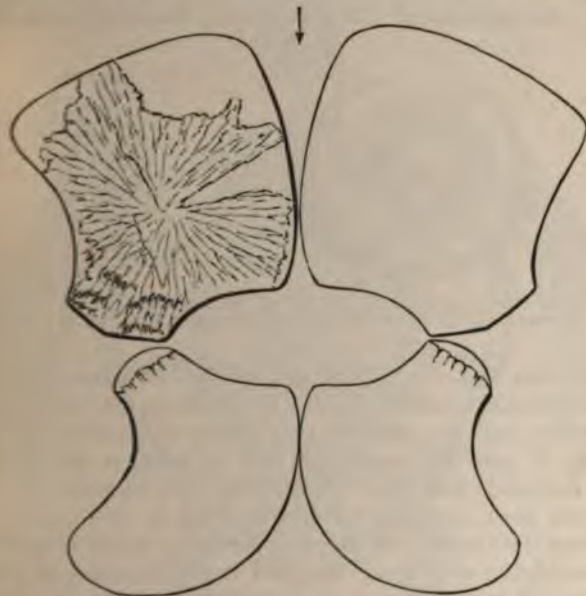


Fig. 1004.—Diagram of the ventral aspect of the pelvic girdle of a young Pliosaur. The upper bones are the pubes, and the lower the ischia. In the adult the ischia become more elongated, and their inner borders should have been placed more nearly parallel. (After Phillips.)

devoid of ridges. The neck is very short, and all the cervical vertebræ (fig. 1005) are relatively large, with nearly flat terminal faces to the very short centra, which in the anterior region have two distinct and often very prominent costal facets. A peculiar feature of all the vertebræ is, that the arches were only articulated to the centra by cartilage, so that they are always found detached. The pectoral girdle was of the general type of that of *Peloneustes*, but it is not improbable that the interclavicle was absent. The humerus was shorter than the femur, and the radius and ulna in the Kimeridgian forms have become much shorter than in that genus, and have scarcely any interv space, but in one of the species from the Oxford Clay have the same form as in the latter. The general arrangeme the ventral bones of the pelvis is shown in the woodcut. I huge *P. macromerus*, of the Kimeridge Clay, the length o lower jaw was nearly six feet, and that of the femur one ya which some estimate can be formed of the gigantic dime attained by the entire animal. Pliosaurs were widely distri over Europe, and have been described from England, Ge (as *Ischyrodon*), France (as *Liopleurodon*), and Russia (as *Spo saurus*). No remains of this genus have, however, been hi

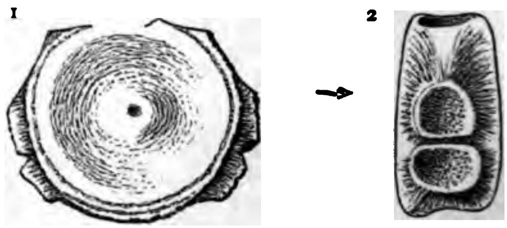


Fig. 1005.—Anterior (1) and lateral (2) aspects of an anterior cervical vertebra of *Plio macromerus*; from the Kimeridge Clay. One-fifth natural size. (After Phillips

recorded from America. The less specialised characters o Oxfordian forms, as shown by the structure of the teeth, an longer radius and ulna, indicate affinity with *Peloneustes*.

Finally, it may be mentioned that in addition to the r already recorded the terms *Piptomerus*, *Orophosaurus*, and *nautes* have been applied by Professor Cope to Sauropterygia mains from the Cretaceous of North America; while a tooth the Kimeridgian of France, described under the name of *Ha saurus*, has likewise been shown to belong to this order, alth originally regarded as Crocodilian.

ORDER III. CHELONIA.—With the Tortoises, Turtles, and allies, we enter upon the consideration of the first of the ex orders of Reptiles. In this order the cervical and dorsal ver are not numerous; the body is short and wide, and has a mo less complete bony shell, of which the ventral part, or plastron, sists of few elements of dermal origin, while the dorsal, or cara may be in great part of endoskeletal origin. There is gener horny epidermal exoskeleton. The skull may occasionally hav temporal arcades, but more generally only the lower one is pr (fig. 1007), and in some cases even that may be absent. The (fig. 1024) are single and terminal; the premaxillæ very small there is no parietal foramen in the adult; but there is a di isthotic bone (fig. 1024). The dentary bones of the mandible e generally fused together; the postorbital is welded with the post-ontal, and usually the prefrontal with the nasal; while the supraoc-ipital is prolonged backwards. There is no transverse bone. The alate is completely closed by the junction of the pterygoids with he basisphenoid, and often with one another (fig. 1017 *bis*). In all isting forms teeth are absent, and the trenchant jaws ensheathed in orn. Each rib articulates at the junction of two vertebræ; there are

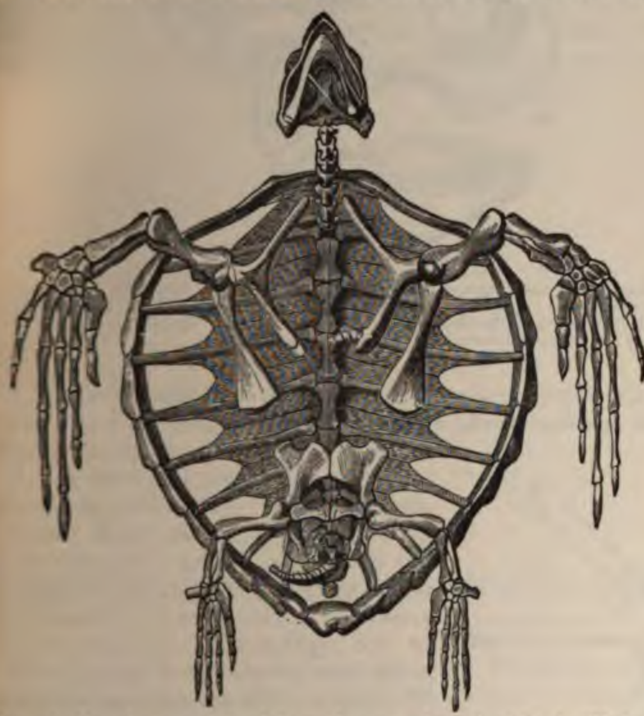


Fig. 1006.—Ventral aspect of the skeleton of a young Loggerhead Turtle (*Thalassochelys caretta*), with the plastron removed. Much reduced. The coracoid and precoracoid of opposite sides are here represented as widely separated from one another. (After Owen.)

no ribs in the cervical region, and no transverse processes to the dorsal vertebræ. The vertebræ may have procœlous, opisthocœlous, or amphicœlous centra in different parts of the column of the same individual. In the pectoral girdle (fig. 1008), which is situated within the ribs, the coracoid is the widest of the three cartilage bones; and he coracoid and precoracoid of opposite sides are respectively con-ected in the middle line by ligamentous tissue only. The con-ection between the scapula and precoracoid is short, and there is no trace of a sternum. In the plastron (fig. 1009), developed the ventral aspect, the *epiplastrals* (*es*) and *entoplastral* (*s*) cor-spond to the three plates of the Labyrinthodont thoracic buck

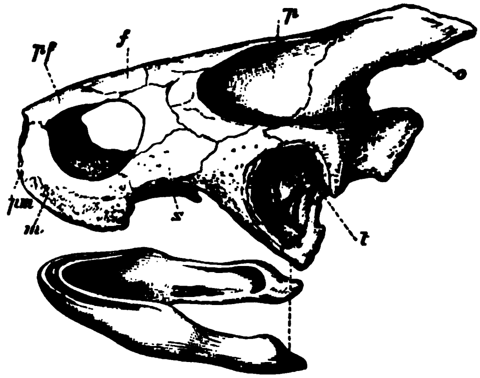


Fig. 1007.—Left lateral aspect of the skull of *Testudo*. *pm*, Premaxilla ; *m*, Maxilla ; *pf*, Prefrontal and nasal ; *f*, Frontal ; *p*, Parietal ; *o*, Supraoccipital ; *s*, Jugal, behind which is the quadratojugal, and above the postfrontal ; *t*, Quadrate, showing the incompleteness of the tympanic ring posteriorly ; the bone above this ring is the squamosal.

and apparently represent the clavicles and interclavicle. There are in addition paired *hyo-*, *hypo-*, and *xiphiplastrals* ; and in some forms (fig. 1012) there are *mesoplastrals* intercalated between the hyo- and hypoplastrals. The pelvic, like the pectoral girdle, becomes in the adult placed on the inner side of the ribs, and has the pubis much larger than the ischium (fig. 1006). The two latter may be anchylosed to the xiphiplastral, and the obturator notch may be converted into a foramen. The humerus has an ectepicondylar groove, which is occasionally converted into a foramen. There is a centrale in the carpus (fig. 829), and in the *Chelydridæ* also in the tarsus. The tarsus may probably be regarded as having five distinct tarsalia, as in the Amphibia and *Mesosaurus*. In both the manus and pes there are always five digits, with a variable number of phalangeals. Not unfrequently the bones of the palate develop inferior plates to floor the nasal passage, and thus produce secondary posterior nares with a vertical aperture. Since the palæonto-

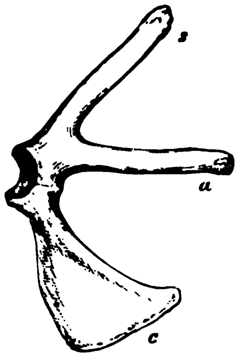


Fig. 1008.—Right side of the pectoral girdle of *Testudo*. *s*, Scapula ; *a*, Precoracoid ; *c*, Coracoid.

gist generally has to deal with what is frequently and conveniently termed the *shell*,—that is, the carapace and plastron together,—attention must be more particularly directed to its structure in the more typical forms. Commencing with the epidermal skeleton of those forms in which this is fully developed, we find that it consists of horny shields, which usually have their edges in apposition, but occasionally overlap (fig. 1021). On the upper surface there are five *vertebral* shields in the middle line, on either side of which there are four *costals*; while the border has 24 or 25 smaller shields, of which the median anterior one (when present) is termed the *nuchal*, and the double or single posterior shields are known

Fig. 1009.—Bones of the plastron of *Thalassochelys caretta*. Much reduced. *es*, Epiplastral (clavicle); *s*, Entoplastral (interclavicle); *hs*, Hyoplastral; *ps*, Hypoplastral; *xs*, Xiphiplastal. (After Owen.)

as the *caudals*; the remaining eleven on either side being reckoned as *marginals*. The position of all these shields is exhibited in fig. 1017. On the ventral aspect of the plastron (fig. 1016) there are usually six pairs of shields, of which the most anterior are termed *gulars*, the next *humerals* (*postgulars*); the next *pectorals*; then the *abdominals*; the *femorals*; and finally the *anals*. In some cases, however, there is an additional *intergular* (very rarely double), which is usually (as in fig. 1012) placed between the gulars, but in some cases may be situated below the gulars, being then surrounded by the gulars, humerals, and pectorals, as in *Chelodina*. In the extinct *Archæochelys*, of the Wealden, where the intergular occupies the latter position, there is also a series of apparently single *interpectoral*, *interabdominal*, and *inter-*

femoral shields dividing the normal pairs of plastral shields; a is probable that this may be regarded as the archaic type. Sim in a Chelonian, mentioned below under the name of *Tropid* there is a median series of intervertebral shields dividing the no vertebrals into two lateral rows. In some cases *inframarg* shields separate the marginal from the plastral shields.

The bones of the carapace, although following the same ge arrangement, do not, as will be seen from the figures, by any me

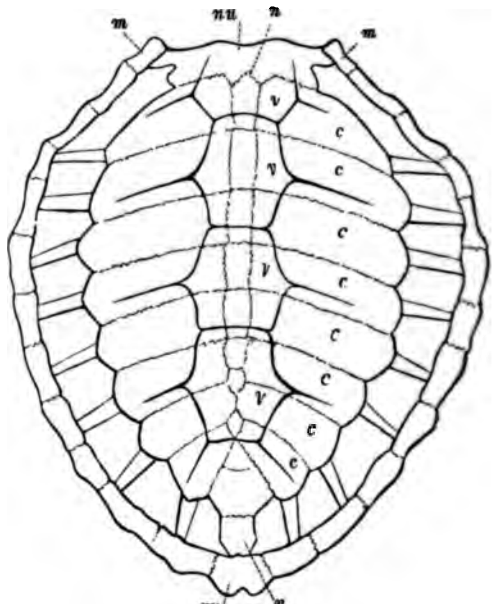
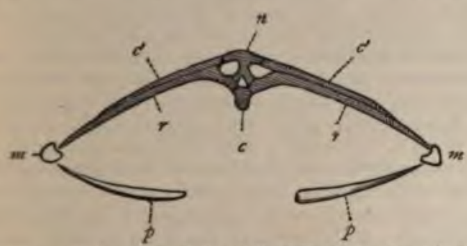


Fig. 1009 *bis*.—Upper surface of the carapace of *Thalassochelys caretta*, with the epidermal shields removed. The dark lines in the middle region indicate the boundaries of the shields, and the sinuous ones the sutures between the bones. *nu*, Nuchal bone; *py*, Pygal do.; the bone above this marked *n* and the next are the suprapygals; above these, the eight neurals, of which the first is marked *n*; *c*, *c*, Costal bones; *m*, *m*, Marginal do.; *v*, *v*, Vertebral shields. Much reduced. (After Owen.)

correspond with the overlying shields. In those forms with a well-developed carapace there are typically (fig. 1017) eight median *neural* bones formed by the expansion of the spines of the dorsal vertebræ (fig. 1010); these being preceded by a *nuchal*, and followed by two or more *suprapygals* and a *pygal*, all of which have no connection with the vertebræ. While, however, the nuchal is a cartilage bone, the pygal and suprapygals are of purely dermal origin. On either side of this median row is a series of from seven to nine nes (fig. 1009 *bis*) formed by the development of a plate on the rface of each rib (fig. 1010); while the sides of the carapace pleted by the eleven *marginals*,[1] which are dermal ossifica-d eight of which receive the extremities of the ribs from the to the ninth. In all young individuals, and in many of the Turtles (fig. 1009 *bis*), the costal bones do not extend to the ies of the ribs, and consequently leave vacuities on the inner the marginals, but in the land Tortoises and their allies (fig. he carapace is entirely bony. In some instances, again, the of neural bones may be reduced (as in fig. 1014, where re but seven), and very rarely they are entirely wanting, so the costals meet in the middle line. The two suprapygals so be reduced to one, as in fig. 1014. Similar variations n respect to the degree of ossification of the plastron; since



10.—Transverse section through the shell of *Chelone mydas*. Reduced. *c*, Vertebral *n*, Expanded neural spine; *r*, Rib; *c'*, Costal bone; *m*, Marginal do.; *p*, Plastron. xley.)

n all young individuals, and in the existing marine forms (fig. throughout a great part or the whole of life there are vacuities en the bones, in the land Tortoises and their allies the bones connected by suture.

the marine Turtles the plastron is totally unconnected with rapace; but in most other forms the hyo- and hypoplastrals up longer or shorter peduncles underlying the marginals, and e cases also the costals of the carapace, and thus form well-d *axillary* and *inguinal buttresses*. These peduncles are t in some of the existing Pleurodira; while the inward prom- of the buttresses is most marked in the Indian Batagurs.

nsiderable variation occurs in the skulls of the different groups, can only be mentioned here that in some genera like *Chelydra Chelone* the supratemporal fossa is more or less completely over by the development of plates extending outwards from rietal and backwards from the postfrontal; this roof being

casionally the number of marginals may be increased to twelve or reduced most complete among existing forms in *Chelone* and *Dermod* where the parietal joins the squamosal. In such cases, in add to the inferior temporal arcade formed by the quadrate, quad jugal, and jugal, as in fig. 1007, there is also a superior arcade stituted by the squamosal and postfrontal. Whereas, however, arcades in the Crocodilia (fig. 1089) are separated by the infr poral fossa, in the Chelonia they are in immediate contact.

The feet may either have all the digits free, or enclosed in a mon integument to form paddles.

The humerus of existing Chelonians is a very peculiar bone acterised by its extremely prominent globular head; but in a Jurassic forms (*e.g.*, *Acichelyidæ*) this head was much smaller, so the bone departs less from a normal type. On either side of this there is a projecting ridge, of which the radial, or preaxial, one (gen termed the lateral process) corresponds with the deltoid crest of the codilian humerus; while the ulnar or postaxial (mesial) process r sents the inner tuberosity of the same. In all Pleurodiran Testud the radial process is comparatively small, and the ulnar process pl in the same transverse line as the distal surface of the bone. In t Cryptodira, however, and more especially in the land Tortoises radial process forms a thin plate extending towards the ventral as and the ulnar process becomes twisted round to the same aspect; causing the pit between the two processes to form a narrow funnel-sh channel instead of being very broad and open. At the same tim shaft becomes extremely curved. In the marine Turtles, where the is nearly straight, the radial process tends to become aborted, a attain a position more or less below the head. In the Athecata, likewise have a nearly straight humerus, the radial process, whil scending on the shaft, tends to an excessive development.

In time this order dates from the Upper Trias; and it attained great development in the Upper Jurassic, from which it appears to have gone on increasing till the later Tertiary.

Considerable diversity of views obtains as to the classifi of the Chelonia, but according to the system now followed i British Museum it may be divided into the two suborders Atl and Testudinata.

SUBORDER I. ATHECATA.—This group contains those forms have been usually regarded as showing the nearest approximat other Reptiles, and therefore representing the most generalise of the order. Dr Baur, however, takes the opposite view, a gards them as the most specialised group, which has tended to or less completely lose the carapace. Before, however, a de opinion can be given on this question it must be determined wl the absence of a bony connection in this group between the pa and pterygoids is to be regarded as an acquired or as an or feature. It may be observed that Dr Baur regards the gro closely allied to the *Chelonidæ*, but if the undermentioned T as *Psephoderma* be rightly referred to it, we have at once a great acle to the acceptance of his view.

The suborder may be briefly characterised by the circumstance the carapace is entirely of dermal origin, and quite separate n the vertebræ and ribs, and may consist merely of a series of rginal bones, or of marginals with a single median dorsal row of ed scutes, or of a number of small irregular scutes, with longi-inal rows of larger ones; while the plastron (fig. 1011) has no oplastral (interclavicular) element. The cranium is characterised the absence of vertical plates connecting the parietals with the erygoids. All the forms are of marine habits, and consequently e extremities of the limbs are modified into paddles like those of e *Chelonidæ*.

Before noticing the two established families, it may be observed at the imperfectly known *Psephoderma* of the Upper Trias of avaria and England is founded on a specimen which appears to e a carapace of a member of this suborder, although it has been ggested that it is not Chelonian at all. This presumed carapace is rmed of a number of polygonal scutes, traversed by longitudinal ows of keeled scutes. Here also may be mentioned the genus *Macrllognathus*, founded upon the anterior portion of a toothed andible from the Upper Jurassic of North America, which Pro-essor Marsh regards as showing affinity with the Chelonia, and which may possibly indicate a generalised family of the present suborder.

FAMILY PROTOSTEGIDÆ.—This family is usually regarded as the least specialised of the two that are yet established, although an opposite view is taken by Dr Baur. The carapace, according to the interpretation of that authority, is represented merely by a row of marginal scutes; but the plastron is strongly developed, and composed of very thick ossifications. The type genus *Protostega* occurs typically in the Cretaceous of North America. It was con-sidered by its describer Professor Cope to have possessed a solid carapace, but the bones which he regarded as probably dorsal appear to belong to the plastron. It was also suggested that the dorsal vertebræ were procœlous, with traces of transverse processes; but these vertebræ are probably referable to the cervical region. The type species attained very large dimensions. An allied form from the Upper Cretaceous of Italy has been described under the name of *Protosphargis* (fig. 1011), but further evidence is required to prove its right to generic distinction from the American form. It has, indeed, been asserted that there were no marginal bones, but according to Dr Baur this is incorrect. In the Cambridge Greensand and the English Chalk there occur humeri of Athecate Chelonians which have been provisionally referred to *Protostega*.

It is uncertain whether the remains from the American Cret
described as *Atlantochelys* belong to the last-named genus.

FAMILY DERMOCHELYIDÆ.—This family is characterised by
a carapace composed either of a median row of large and
scutes and lateral marginal rows, or of a mosaic of small in
scutes, or tessaræ, traversed by longitudinal rows of larger
The plastron varies considerably; and the humerus, which is
flattened type of that of the *Chelonidæ*, is distinguished fro
of the preceding family by the great development of its radi

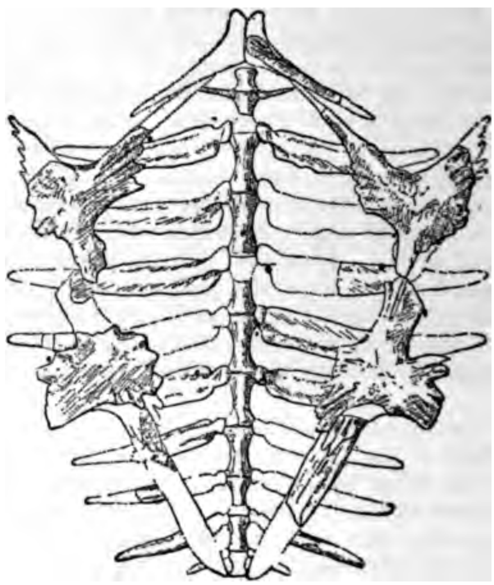


Fig. 1011.—Ventral aspect of the plastron and thoracic region of *Protosphargis vern*
from the Upper Cretaceous of Italy. One-fifteenth natural size. (After Capelli

cess, which is situated near the middle of the shaft. The sk
the temporal fossæ completely roofed, as in the *Chelonid*
an open tympanic ring, but has no bony floor beneath the
passage. Whereas all the members of the preceding family
moderate size, several representatives of the present one a
huge dimensions. The earliest representative is the genus *Eosp*
of the London Clay, of which the one known species was ori
described as *Chelone gigas*. The skull is of the general type
of the next genus, but the carapace apparently consists on
median row of very broad and large carinated scutes, and
a row of marginals; the structure of the plastron is not de

ut it was doubtless devoid of tessaræ. The allied *Psepho-* nging in Europe from the Middle Eocene to the Upper and also found in the Upper Eocene of the United States, erised by the presence of a complete tesselated carapace ron. In the carapace the longitudinal rows of larger scutes arinated, and are more approximated than in the existing he carapace is also thicker than in the latter; and there r marginals. It is also suggested that the carapace may horny epidermal shields. The skull is short and much d. The existing genus *Dermochelys* (*Sphargis*) is represented he well-known Leathery-turtle, and is characterised by the of a tesselated plastron; by the carination of the scutes of r rows of the carapace; by the comparative thinness of the , which is devoid of epidermal shields; and by the longer e vaulted skull. It is, moreover, worthy of note that in in the preceding genus, there is a distinct nuchal bone at rior extremity of the carapace, corresponding to the nuchal 'estudinata; but there are no marginal ossifications. The ting species of *Dermochelys* attains a length of nearly five a species of *Psephophorus* is estimated to have been as s ten feet in length. The skull of *Eosphargis*, although rger than that of *Psephophorus*, does not apparently indicate larger carapace.

RDER 2. TESTUDINATA.—This suborder, for which the name hora[1] is also employed, includes by far the great majority order, or all those forms commonly known as Tortoises, ns, and Turtles. The group is characterised by the middle of the carapace being formed of bony plates, developed y from the ribs and the neural spines of the dorsal vertebræ, h it is firmly welded. The outer surface of the carapace is nerally smooth and overlain by horny epidermal shields, but be sculptured and devoid of such shields. The parietal f the skull in all cases send down vertical descending plates, nay either unite directly with the pterygoids, or be separated m by the intervention of the columella or epipterygoid. It observed that in nearly all the Mesozoic forms the vertebral are very wide, and that this condition obtains in the young later forms. This suborder may be divided into four sec- one, and not improbably two, families of the third section f marine habits.

ION 1. AMPHICHELYDIA.—This section is formed for the n of certain extinct Chelonians, mostly of Mesozoic age, ombine in a remarkable manner the characters of the two fol-

[1] name is objectionable, as being employed for an order of Hydroid es (*vide supra*, vol. i. p. 203).

lowing sections, and may probably be regarded as the survi the earlier ancestral types from which those two sections took They are all characterised by the presence of a mesoplastral and of an intergular shield in the plastron; and the pelvis may not be connected with the xiphiplastrals. The entopla rhomboidal. The skull and cervical vertebræ are unknown.

FAMILY PLEUROSTERNIDÆ.—All the members of this secti be, at least provisionally, included in this family. In addi the characters given above, it may be observed that the s fully ossified, and that the carapace has a complete se neural bones, of which the hindmost articulates with the s suprapygal bone. On th position that the Ch plastron is derived fr system of abdominal ri those of the Rhynchoc and Sauropterygia, it w evident that the meso of the present group archaic feature.

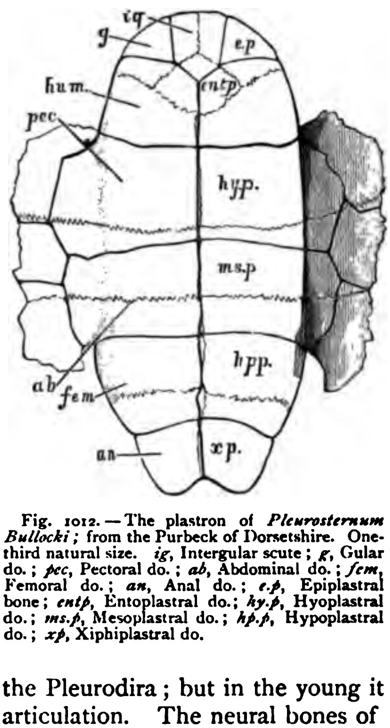


Fig. 1012.—The plastron of *Pleurosternum Bullocki*; from the Purbeck of Dorsetshire. One-third natural size. *ig*, Intergular scute; *g*, Gular do.; *pec*, Pectoral do.; *ab*, Abdominal do.; *fem*, Femoral do.; *an*, Anal do.; *e.p*, Epiplastral bone; *entp*, Entoplastral do.; *hy.p*, Hyoplastral do.; *ms.p*, Mesoplastral do.; *hp.p*, Hypoplastral do.; *xp*, Xiphiplastral do.

In the typical genus *sternum* (*Megasternum* *gerrhum*), which occurs monly in the English Pu and is also found in th land Oolite, the shell is and depressed, with co mesoplastrals (fig. 101 large and wide entoplas single intergular shield, a nuchal shield. In the the pubis articulates smooth facet on the plastral, thus foreshadow complete sutural union occurs between these bo the Pleurodira; but in the young it appears that there was n articulation. The neural bones of the carapace are hexagon comparatively long; while the vertebral shields (as in so m the earlier Chelonians) were relatively wide. Further, infram shields (shown in fig. 1012) were developed between the shi the plastron and the marginal shields of the carapace; wh extremities of the xiphiplastrals were notched. The bones pectoral girdle and the humerus approximate to those of the e Pleurodiran genus *Chelys*.

Much confusion has arisen in regard to this genus owing to a plastron having been described under the name of *Platemys Bullocki*, under the erroneous impression that it had been obtained from the London Clay. Remains of *Pleurosternum* are extraordinarily abundant in the Purbeck of Dorsetshire; and include specimens of all sizes, from the newly hatched young, with a carapace of a couple of inches in length, to adult specimens which are close upon twenty inches. Curiously enough, however, no specimen of the skull seems to have been obtained. The young appears to have differed considerably in the details of the shell from the adult; thus, not only was the pubis, as already mentioned, entirely unconnected with the plastron, but the marginal bones encroached in a remarkable manner upon the front of the nuchal. Moreover, it seems that in very young individuals the vertebral shields were divided in the middle.

In *Helochelys*, of the Lower Greensand of Bavaria, we have another genus also furnished with complete mesoplastrals, but apparently without any articulation between the pubis and the plastron. The shell is ornamented with a pustular sculpture resembling that found in the genus *Tretosternum*, mentioned below among the *Chelydridæ*. The plastron differs from that of *Pleurosternum* in that the xiphiplastrals were not notched; and there appears to have been a nuchal shield.

The next two genera, constituting the family *Baënidæ* of Professor Cope, may be at least provisionally placed here. Both are devoid of a bony attachment between the pelvis and plastron. The genus *Platychelys* (*Helemys*), typically from the Lower Kimeridgian lithographic limestone of the Continent, is readily distinguished by the number of irregular ridges and prominences on the carapace (fig. 1013), and by the width and irregular contour of the neural bones. The mesoplastrals are small, and widely separated in the middle line; and the intergular shield is single.

The genus *Baëna*, from the Eocene of the United States, has the mesoplastrals meeting only by a point in the middle; and is further remarkable for the presence of double intergular shields, and the presence of a small additional costal shield in advance of the normal first costal. The caudal vertebræ are opisthocœlous. Professor Cope, who places this genus in the Cryptodira, regards it as indicating a generalised type, showing marked signs of affinity with the Pleurodira, and exhibiting traces of an imperfect connection between the pelvis and the plastron. The extinct North American genus *Polythorax* should perhaps be also placed in this family, although it is not certain that it is not allied to the Cryptodiran *Adocus*.

Here also may be mentioned the very imperfectly known genus *Archæochelys*, of the English Wealden, in which, as observed above,

the paired shields of the plastron were separated by a median
of azygous shields, which probably extended backwards from
tergular to the extremity of the xiphiplastral. If the separate
are rightly interpreted, it would appear that the plastron
mesoplastral element, which, instead of being situated in the
of the bony bridge as in *Pleurosternum* (fig. 1012), and tak
part in the formation of the axillary notch, formed the anteri
of this bridge and the whole of the notch. The hyoplastral
therefore be entirely above the latter notch, as in the existing

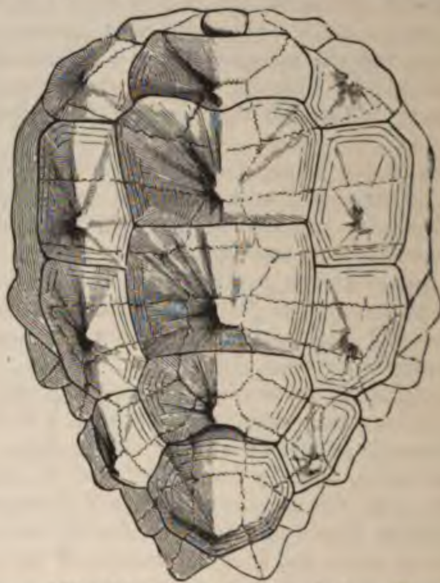


Fig. 1013.—Carapace of *Platychelys Oberndorferi*: from the Lower Kimeridgian of
One-third natural size. (After Wagner.)

rodiran genus *Sternothærus*. Possibly also a Chelonian, fr
Lower Jurassic of Stonesfield, described, upon the evidence
impressions of the epidermal shields of the carapace, und
name of *Testudo Stricklandi*, should also find a place in this
The name *Protochelys* may be proposed for this form, whi
certainly nothing to do with *Testudo*.

SECTION 2. PLEURODIRA.—The members of this section
a rule, characterised by the complete ossification and union
carapace and plastron, and by the full development of the m
bones, which are connected with the ribs, as well as by the
union or anchylosis (synostosis) of the pelvis with both the ca
and the xiphiplastral part of the plastron. Very frequently t

apygal bone, and some (fig. 1014) or occasionally all of the ral bones are absent; and when epidermal shields are developed intergular (as in fig. 1012) is present on the plastron. This eld is, however, sometimes found in the next section, in which neurals may also be reduced in number. The entoplastral ie (as in the preceding section) is either oval or rhomboidal; a mesoplastral bone (compare fig. 1012) may be present.

n the skull of existing and Tertiary types the tympanic cavity is mpletely surrounded by the quadrate, which forms an unbroken g; the articular surface of the quad-e has a concavity for the reception of condyle on the mandible; the pteryg-ls are very broad and wing-like; the mer may be absent, so that the pala-es may meet in the middle line; and ere may be distinct nasals, and a suture the mandibular symphysis. The cer-cal vertebræ have well-developed trans-rse processes, and single terminal ar-culations; while there are never more an three phalangeals to the digits.

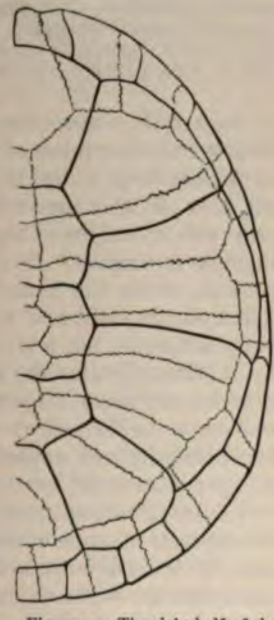


Fig. 1014.—The right half of the carapace of *Sternothærus nigricans*; from Madagascar. The thick lines indicate the boundaries of the epidermal shields.

The Pleurodira are further character-ed by their inability to retract the head irectly within the carapace; but the eck is bent on one side and the head us brought within the margin of the hell. In all cases the labyrinth of the ar is completely open from behind.

At the present day this section is al-most exclusively confined to the southern hemisphere; but in the Eocene forms more or less nearly allied to existing types were widely spread over the north-ern hemisphere, and in the Mesozoic there were many European representa-tives of the group. With the exception of *Podocnemis*, the existing forms are carnivorous, and the whole of them are thoroughly aquatic.

At least one of the two earliest known genera of Testudinata has been referred to this section; and from the occurrence in many existing forms of separate nasals, and of a mesoplastral bone, we may regard this sec-tion as retaining evidence of a close alliance with a primitive generalised type which has been lost among existing Cryptodira, since it is nearly certain that features like these if once lost would not reappear, except as abnormalities. The presence of transverse processes to the cervical vertebræ would also seem to be a generalised character; and, fr evidence afforded by the above-mentioned *Pleurosternum* and *A chelys*, the presence of an intergular shield should probably be l regarded in the same light. The anchylosis of the pelvis to the p as pointed out by M. Dollo, would, however, seem to prevent u regarding the Pleurodira as the ancestors of the Cryptodira; a more probable that both sections should be regarded as div branches of a common stock, probably represented by Amphiche earlier age than those yet known.

It would seem probable that the palate of the earlier Mesozoic P dirans approximated to the Cryptodiran type, and that the peculiar dibular articulation and closed tympanic ring of the existing for acquired features. The skull of the Mesozoic types appears gener have been roofed over after the fashion of the modern Turtles; this ture having apparently been common to many of the earlier forms of this and the following sections of the suborder.

FAMILY PROGANOCHELYIDÆ.—This name is proposed by Baur for the reception of the genus *Proganochelys*, from the K of Würtemberg, which he regards as a Pleurodiran, although d ing from all other members of the section in that the plastron only with the edges of the marginals, without giving off axillary inguinal buttresses. It is suggested that mesoplastral bones present, while the carapace is compared to that of *Platych* The latter resemblance suggests that this form might belong to Amphichelydia, but a study of the figure of the type specimen g by Professor Quenstedt, under the synonym of *Psammochelys*, sh that its extremely imperfect nature scarcely permits any deci opinion to be formed as to its true affinities. Whether the imp fectly known and apparently aberrant genus *Chelytherium* of Keuper is an allied form cannot yet be determined.

FAMILY PLESIOCHELYIDÆ.—This Mesozoic family is character by the total absence of the mesoplastral element in the plastron, also by the circumstance that the pubis alone is united with xiphiplastral; while there may or may not be a complete series neural bones articulating posteriorly with the suprapygal. The pl tral shields are separated from the marginals by the intervention a series of inframarginals; and the plastron, as in the succeed families, is connected by long buttresses with the carapace. T humerus is of the type found in existing Pleurodira; and the sec digit of the manus, when known, has but two phalangeals. T skull is known only in a few cases with certainty.

The typical genus *Plesiochelys* and the closely allied *Craspedoch* were originally described from the Lower Kimeridgian Lithogra limestones of Bavaria and France. These genera have a thick sh with the full complement of neural bones, which posteriorly join first suprapygal, and with the vertebral shields of the carapac moderate width. The entoplastral bone is relatively wide ded; the nuchal is but slightly emarginate; and the intergular d is double. The surface of the carapace is usually marked by gs. Some at least of the Chelonians from the Kimeridgian of over which have been described under the preoccupied name *tylemys* may be included in *Plesiochelys*, and this genus is also sented in the English Wealden.

llied Chelonians, from the Kimeridgian of Hanover, described r the name of *Chelonides* (likewise preoccupied), not improbably cate forms connecting *Plesiochelys* with the undermentioned *æochelys*. In one specimen referred to the type species of *Chel-des*, there are but seven neural bones; but the vertebral shields narrower than in typical species of *Hylæochelys*. If these forms really entitled to rank as a distinct genus they require a new ne. A skull said to have been associated with the shell of the e species of *Chelonides* has the temporal fossæ roofed over by e, while the palatines are described as meeting in the middle after the manner of many existing Pleurodira. From the occur-ce of *Plesiochelys* and the undermentioned *Hylæochelys* in the alden, and the apparent rarity of the *Acichelyidæ* in the same ls, it is probable that the members of this family were of fresh-ter habits.

It is probable that the genus *Parachelys* of the Lithographic Lime-ne (which was considered by Professor von Zittel to be indis-guishable from *Acichelys*) is really identical with *Plesiochelys*; in ich case the former name should supersede the latter, and the mily name *Parachelyidæ* replace *Plesiochelyidæ*. The humerus of s genus resembles that of recent Pleurodira, and is widely different om that type of humerus which appears to be referable to the *Acichelyidæ*. The number of the phalangeals in the digits of the anus of this form (and also in *Idiochelys*) is 2, 2, 3, 3, 3; and this resents a decided approximation to the existing Pleurodiran genus *Pelomedusa*, which differs from all other freshwater forms now living n that there are only two phalangeals in each digit.

The name *Hylæochelys* has been proposed for an allied genus of Chelonians typically represented by the so-called *Pleurosternum latiscutatum* of the English Purbeck, which as shown by a shell om the Wealden preserved in the British Museum, belongs to the resent family. This genus is distinguished from *Plesiochelys* by the uch wider vertebral shields of the carapace, in which the width ay exceed three times the length; and also by the narrower and amond-shaped entoplastral bone; as well as by the circumstance at the neural bones, at least usually, do not join the suprapygals, d are generally interrupted in the middle of the series; while the poplastral bone is relatively shorter. Both in this and the pre-ding genus there may be a vacuity in the middle of the plastron.

It would appear that the Purbeck form described as *Pleuro*
emarginatum, as well as the Wealden specimens to which the
Chelone Belli (*costata*), and *Platemys Dixoni* and *Mantell*
been applied, are likewise referable to *Hylæochelys*. It is, mo
very probable that a Chelonian, from the Upper Greensand of
to which the name *Plastremys* has been given without descrip
also referable to this genus.

The genus *Idiochelys* (*Chelonemys*) and the allied *Hydrop*
the Lower Kimeridgian of the Continent, would appear to be
allied to the preceding. *Idiochelys* resembles *Hylæochelys* in
tremely wide vertebral shields, and also in its small and dis
shaped entoplastral bone, but differs in that the number of
bones is generally much reduced, so that many of the costal
in the middle line; while there are also differences in the c
of the lower plastral shields. This genus, which is known o
immature specimens, was indeed regarded by Professor Rüt
as essentially Pleurodiran, although there was no absolutely d
evidence in support of this view. The shell is thinner than in
chelys; and the skull has the temporal fossæ roofed over by
and apparently had a long sutural union between the postfront
parietal.

Mesozoic Chelonians of Uncertain Position.—It will l
venient to notice in this place several Mesozoic Chelonians
known to us only by the skull, of which the serial position
at present be determined. A large skull from the Portland
originally described as *Chelone platyceps*, but subsequently ma
type of the provisional genus *Stegochelys*, is characterised
incomplete roofing of the temporal fossæ, and the meet
the prefrontals in the middle line, while it is stated to have
nasals. The palate is unknown. The size of this specime
gests that it may perhaps be referable to the Cryptodiran
Thalassemys of the Kimeridgian.

In the Wealden of Belgium there occur remains of young C
ians to which the name *Chitracephalus* has been applied. T
no mesoplastral bone; and the skull is characterised by its elo
form, open temporal fossæ, and the approximation of the or
the nares.

In the Upper Cretaceous genus *Rhinochelys* the shell i
known by fragments. The skull (fig. 1014 *bis*) has an i
temporal arcade, the temporal fossæ are completely roofe
the palatines meet in the middle line, the nasals are distinc
the prefrontals, which are separated from one another
frontals, the pterygoids are comparatively narrow, and l
emarginate, while the symphysial suture of the mandible i
terated. The humerus is of the Pleurodiran type found in

rr. It has been suggested that this genus is Pleurodiran; and his prove to be the case it will be interesting as showing an ap-ximation in several cranial features to the Cryptodira. In its plete roof the skull of this genus approximates to the *Chelonidæ*. nains of *Rhinochelys* are very abundant the Cambridge Greensand, and they also met with in the Gault and the wer Chalk. Fragmentary Chelonian lls from the Cambridge Greensand, which the name *Trachydermochelys* been applied, are not improbably erable to this genus. They are char-erised by their pustulate external sur-e; the pustules being much larger n in the Amphichelydian genus *Helo-dys* of the Lower Greensand. A mewhat similar, although less marked, stulation occurs in the existing *Chelo-na*.

Fig. 1014 *bis*.—The cranium of *Rhinochelys cantabrigiensis*, imperfect posteriorly; from the Cambridge Greensand. *pa*, Parietal; *pt.fr*, Postfrontal; *fr*, Frontal; *p.fr*, Prefrontal; *na*, Nasal; *mx*, Maxilla; *pmx*, Premaxilla.

Family Pelomedusidæ.—Reverting the consideration of undoubted Pleu-dirans the present existing family agrees th the Amphichelydian *Pleurosternidæ* the presence of mesoplastral bones, but is distinguished in at both the pubis and ischium have a sutural union with the phiplastral. The shields of the plastron, as in the next family, e in contact with the marginals, owing to the absence of infra-arginals. The skulls of existing types have an infratemporal cade, and in *Podocnemis*, alone among existing representatives the section, the temporal fossæ are roofed over; moreover, the efrontals are in contact in the middle line and are fused with e nasals; the palatines, owing to the absence or abortion of e vomer, meet; and the suture between the dentary bones of e mandible is obliterated. The second cervical vertebra is nphicœlous; and the neck is completely retractile within the ell. Further, the series of neural bones, as in the next family, is complete and is not connected with the suprapygals. Finally, in th this and the next family the characters of the tympanic and latal regions of the skull are those mentioned at the commence-ent of the description of the Pleurodira. The earliest known presentatives of this family occur in the Upper Cretaceous of the nited States, where we meet with forms apparently closely allied the existing *Podocnemis*. The genus *Bothremys* has been described on the evidence of a skull from those deposits; while the name *phrosphys* has been applied to portions of the carapace and plastron which not improbably belong to the same form. *Bot* differs from *Podocnemis* by the presence of a distinct vomer. not improbable that allied forms occur in the Cretaceous o Zealand. The only existing genus which appears to be represe a fossil state is the above-mentioned *Podocnemis*, of South A and Madagascar, which occurs in the London Clay and the E of Northern India. This genus includes the largest existing sentative of the section. The carapace has seven neural l and the mesoplastrals are small, and do not meet in the m line. The shell of a large Chelonian from the London Clay, has been referred to this genus under the name of *P. Del* may not improbably belong to the genus *Dacochelys*. The h founded on a mandibular symphysis from the same deposit is characterised by a large spine-like process on its oral and the serrated margins of the alveolar borders. Its serial depends on whether it is specifically identical with the mentioned shell.

FAMILY CHELYIDÆ.[1]—In this family the shell is much t than in *Plesiochelys*, and is characterised by the absence mesoplastrals, and the reduced number of neural and supr bones; while both the pubis and ischium unite with the pl The skull has an incomplete inferior temporal arcade, owing absence of the quadratojugal; and is further distinguished separation of the prefrontals by the frontals; the distinct (except in *Chelys*); by the vomer dividing the palatines; a the persistence of the suture in the mandibular symphysis. temporal fossæ are open, but there is an arch connecting the p with the squamosal, not found in the *Pelomedusidæ*, and wh probably a remnant of the earlier type of roof. The fifth and cervical vertebræ are biconvex. The neck cannot be fully ret within the carapace. As typical genera we may notice the American *Chelys*, *Hydraspis*, and *Platemys*; and the Aus *Chelodina*, *Emydura*, and *Elseya*, in which neural bones are a Remains of *Chelodina* and *Emydura* occur in the Pleistoc Australia; while *Hydraspis* is found in a fossil state in the Eocene of India, and *Platemys* has been recorded from the ceous of North America.

FAMILY MIOLANIIDÆ.—This is an extinct family represente by the remarkable *Miolania*, from the Pleistocene of Austra which the remains were originally referred to the large *Vara* the same deposits. This family, according to Mr Boulenger, oc a position in the present section somewhat analogous to that by the *Chelydridæ* among the Cryptodira; the caudal ve

[1] Frequently incorrectly given as *Chelydidæ*.

ing opisthocœlous and the temporal fossæ of the cranium roofed over by bone. The cranium (fig. 1015) is remarkable for carrying several pairs of horn-like processes (on which account the name *Ceratochelys* has been proposed); and the tail was protected by a close bony sheath (fig. 1014), somewhat resembling that of the Glyptodont Edentates. The species of which the skull is shown in the woodcut must have attained huge dimensions. The carapace and plastron are known only by fragments. From the structure of

B A

Fig. 1015.—*Miolania Oweni.* A, Anterior view of cranium; B, Right lateral aspect of the extremity of the caudal sheath; from the Pleistocene of Australia. Much reduced. (After Owen.)

the jaws it is inferred that *Miolania* was herbivorous; while the form of the terminal phalangeals and the solid caudal sheath are indicative of terrestrial habits. The bones of the pelvis are fused into an innominate bone, and some of the cervical vertebræ had two transverse processes.

It should be observed that Dr Baur dissents from the view that this genus is a Pleurodiran, and would refer it to the Cryptodiran family *Testudinidæ*; but there appear to be several misconceptions in the arguments adduced in support of this view. Sir R. Owen does not, indeed, recognise the Chelonian nature of *Miolania*, and regards it as constituting a distinct group, under the name of Ceratosauria; but this view is altogether at variance with the facts, and there can be no question but that the genus is a true Chelonian.

Family Carettochelyidæ.—The last family of the Pleurodira is characterised by the absence of horny shields, and is typically represented by *Carettochelys* of New Guinea, in which the neural bones are very small and do not touch one another, and the limbs are paddle-shaped. In the Lower Eocene of Northern India we find the extinct genus *Hemichelys*, which differs from *Carettochelys* in having seven large neural bones in contact with one another; the nature of the limbs being unknown.

Section 3. Cryptodira.—In this section the ossification of the carapace and plastron may be either imperfect or complete, and the two may or may not be connected at their edges; there is no bony attachment of the pelvis to the plastron; and as a general rule, the full complement of suprapygal and neural bones is present, a there are numerous exceptions. Excluding the Amphict forms, no known Cryptodiran has a mesoplastral bone, v the majority of cases, especially among existing types, tl tron has no intergulai (fig. 1016). The ento when present, is eithe rhomboidal (fig. 101 ✝-shaped (fig. 1009), a epiplastral joins the l tral. In the skull (fig the outer border of tl panic cavity is always notched posteriorly; th rate articulates with cavity in the mandibl the pterygoids are c tively narrow and l emarginate. There a more than three pha in the digits. The sa caudal ribs (as in the dira) articulate partly v centra and partly w arches of the vertebræ the cervical vertebra very imperfectly de transverse processes.

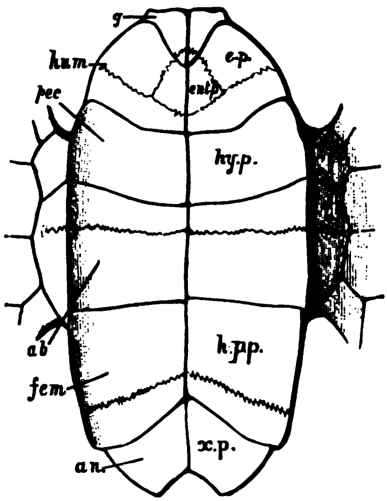


Fig. 1016.—Plastron of *Kachuga tectum*; from India. One-half natural size. *g*, Gular shield; *hum*, Humeral do.; *pec*, Pectoral do.; *ab*, Abdominal do.; *fem*, Femoral do.; *an*, Anal do.; *e.p*, Epiplastral bone; *ent.p*, Entoplastral do.; *hy.p*, Hyoplastral do.; *h.pp*, Hypoplastral do.; *x.p*, Xiphiplastral do.

isting Cryptodiran has distinct nasals, and at present ther decisive evidence of the presence of these bones in any fossi

The Cryptodira are further characterised by their power of ing the head by a sigmoid curvature of the neck in a vertic directly within the carapace. This large section comprises t majority of the existing Testudinata, and at the present mainly characteristic of the Northern Hemisphere, being absent from Australia. The habits of existing Cryptodii be carnivorous or herbivorous, and either terrestrial, fluvi marine.

Family Acichelyidæ.—Under this name may be grc number of generalised Cryptodirans often spoken of as the *semydes*, and in some cases as the *Eurysternidæ*. They occ cally in the Lower Kimeridgian Lithographic Limestones of tl tinent, and are abundant in the Kimeridge Clay, while they s till the period of the Lower Greensand. They were p mainly of marine habits, since they appear to be very rare rater Purbeck and Wealden beds. They are characterised by nore or less heart-shaped carapace, of which the costals are imperfectly ossified, and do not unite completely with the nals. The plastron has, moreover, a vacuity in the centre, persists for a long period or throughout life, but it had large ry and inguinal buttresses for connection with the carapace. humerus has a very imperfectly developed head and a slightly d shaft; and the limbs were not modified into paddles. The al bone of the carapace has no costiform processes; and the oral fossæ of the skull were more or less completely roofed by bone.

their cordiform, and frequently imperfectly ossified carapace, *Acichelyidæ* agree with the modern *Chelonidæ;* and since the iar form of the neurals of *Tropidemys* is another feature only with elsewhere in the latter family, there are strong grounds for ding the one family as the direct ancestor of the other. This y also exhibits certain signs of affinity with the Pleurodiran *chelyidæ;* while the simplicity of the humerus is a very general-character.

e genus *Thalassemys*, which includes some very large forms, is cterised by its long and flat neural bones, in which the anterior l surfaces are much shorter than the posterior ones; while the bral shields are narrow. The carapace is well ossified, and of derable thickness. The type species occurs both in the Litho-ic Limestone and the Kimeridge Clay of England; the unde-d Chelonian from the latter deposit at Ely, to which the name *iochelys* has been applied, being apparently identical. As al-mentioned, the Portlandian *Stegochelys* may likewise be the ; and the genus is represented in the Dorsetshire Purbeck. In ypical genus *Acichelys* (*Eurysternum*,[1] *Achelonia*, *Palæomedusa*, *Nax*) the neural bones of the carapace are flat, with short and indistinct antero-lateral surfaces, and the costals are well ossi-the vertebral shields of the carapace being comparatively wide. genus seems to be confined to the Lithographic Limestone.

Pelobatochelys, of the Kimeridge Clay, we have a large form a very imperfectly ossified carapace, in which the costals are nely thin, and the neural bones are long and six-sided. The -lateral surfaces of the neurals are much shorter than the ro-lateral, and in the fifth neural the latter surfaces are deeply ated. The neurals, especially in the hinder part of the cara-are strongly ridged, having the form of the ridge-tiles of a and the hinder part of the whole carapace is itself roof-like. ertebral epidermal shields were very wide, and the borders of

[1] This name is the earliest, but is preoccupied.

the areas which they overlie on the carapace are conspicu fluted. The last genus, *Tropidemys*, while having the roo posterior neurals of *Pelobatochelys*, is distinguished by the regularly hexagonal form of these bones, owing to the length of the anterior and the shortening of the posterior lateral su One species from Hanover referred to this genus shows the u feature of a median row of numerous small intervertebral s dividing the normal vertebrals into two lateral series. This occurs in the Lithographic Limestone, in the English Kim Clay, and the Lower Greensand of Switzerland (*T. valangini* The detached neurals are readily distinguished not only by shape, but by their excessive thickness.

FAMILY CHELYDRIDÆ.—This family is confined at the p day to North, and part of South America, where it is repre by the Alligator-terrapins (*Chelydra*), and the larger Snapper (*clemmys*). The skull is more or less triangular, and very behind; the temporal fossa is partially roofed over, but the mosal is widely separated from the parietal; the bones of the do not develop plates to floor the narial passage; and the tym ring of existing forms, like that of the *Testudinidæ*, is in grea closed behind. The nuchal bone of the carapace develops rib-like (costiform) process on either side, which underlies the ginals; and the complete union of the marginals with the does not take place for a long period; while in the pl vacuities frequently persist till late in life, and the plastron may be relatively small, and unites with the carapace by gomp the hyo- and hypoplastrals not giving off buttresses to underl carapace. In existing forms the caudal vertebræ are opisthoc and there is no bony union between the ischium and pubis same side to enclose an obturator foramen. The head can completely retracted within the shell. The humerus is not flat and has its radial and ulnar processes large, and directed t the ventral aspect.

If all the genera provisionally included in this family are referred, it will be the oldest representative of the order whi exists. The genera may be divided into three subfamilies, a ing to the presence or absence of sculpture or epidermal shie the shell. It is, however, by no means certain that all these should be included in this family; but until we know the sk caudal vertebræ of all the genera it is impossible to deci point, and it may eventually prove that there is a more or les plete passage to the *Dermatemydidæ* from this family, since already are some indications of a connection between them. the American Cretaceous genus *Toxochelys* is stated by Dr I be a true Chelydroid, but to have the procœlous caudal ve

Dermatemys, and also to have an open tympanic ring. The *Anostirinæ* are typically represented by *Anostira*, of the Upper Eocene of North America and England, and we may probably include in the same group *Pseudotrionyx* (*Apholidemys*), of the Middle and Lower Eocene of Europe. In these forms the shell has a vermiculated sculpture, but epidermal shields appear to be absent, although Dr Baur states there are traces of them in the typical genus; the plastron is well developed; and the neural bones are reduced to seven, as in *Dermatemys*. *Anostira*, which, on account of the presence of only ten marginal bones, Dr Baur places in the *Dermatemydidæ* (*Staurotypidæ*), differs from *Pseudotrionyx* by the sculpturing of the neural bones. The skull of *Pseudotrionyx*, originally referred by Sir R. Owen to *Platemys*, agrees essentially with that of *Macroclemmys*, although the orbits are less lateral. The second subfamily, *Tretosterninæ*, is represented by *Tretosternum*, of the English Wealden and Purbeck, with which *Peltochelys*, of the Wealden of Belgium, is identical. Possibly the imperfectly known North American Cretaceous genus *Compsemys* may prove to be a closely allied, if not identical, type. The shell is studded with granular tubercles, and has epidermal shields; while the plastron is larger than in the *Chelydrinæ*, and has an intergular shield. This is, however, accompanied by only five paired plastral shields, as in *Dermatemys*, instead of the six found in *Pleurosternum* (fig. 1012). The nuchal bone is deeply emarginate.

Finally, in the typical subfamily *Chelydrinæ* the shell is not sculptured, and has epidermal shields; the plastron is relatively small, and generally has a median vacuity; while there is the full number of eight neural bones, of which the last articulates with a suprapygal, and thus prevents any of the costals from meeting in the middle line. The type genus *Chelydra* is represented in the Puerco or Lowest Eocene of the United States, and also occurs in the Upper Miocene of Switzerland, the Middle Miocene of Styria (where it has been described as *Chelydropsis*), and the Lower Miocene of Rott, near Bonn. No fossil forms have hitherto been referred to *Macroclemmys*, which is distinguished from *Chelydra* by the more deeply emarginate nuchal, and the lateral orbits of the skull, which is very large in proportion to the shell and limb-bones.

Family Cinosternidæ.—With the American genus *Cinosternum* we come to a family readily distinguished by the total absence of the entoplastral element of the plastron. In the existing genus the skull has open temporal fossæ, the nuchal has a costiform process like that of the *Chelydridæ*, the pelvis is of a Testudinate type, and the caudal vertebræ are procœlous. The absence of the entoplastral also occurs in the Swiss Eocene genus *Dithyrosternum*, which has accordingly been placed in the same family. It is distinguished from

Cinosternum by the presence of eight neural bones, and the l[...] bridge connecting the carapace with the plastron.

FAMILY DERMATEMYDIDÆ.—The genus *Dermatemys*, of Ce[...] America, is taken as the type of a family which includes *St*[...] *typus* of the same region, and in some respects connects [...] *Cinosternidæ* with the *Chelydridæ*. The nuchal bone has a c[...] form process, as in both those families; the temporal fossæ of [...] skull are not roofed over; the caudal vertebræ are procœlous; [...] in the pelvis the pubis and ischium of the same side do not [...] to enclose an obturator foramen. The shell is well ossified, but [...] the type genus the union between the costals and marginals d[...] not take place till a late period. *Baptemys*, of the Upper Eoc[...] of North America, which has been included by Professor Cope [...] *Dermatemys*, is distinguished from the latter by having the [...] number of neural and suprapygal bones, so that none of the cost[...] meet in the middle line. Here may be mentioned several al[...] North American forms, most of which are referred by Profes[...] Cope to a distinct family—the *Adocidæ*—mainly on account of t[...] circumstance that the ribs do not develop heads to articulate wi[...] the vertebræ; but since the same feature occurs in *Testu*[...] among the *Testudinidæ*, it cannot be regarded as of family valu[...] In *Homorophus*, of the American Cretaceous, there is no inte[...] gular shield, and the vertebral shields are very narrow. In *Ado*[...] of the Upper Cretaceous, and *Agomphus* (with which Dr Baur stat[...] *Amphiemys* is identical), of the Eocene, intergular shields were present. The former has traces of sculpture on the shell; while in the latter the epidermal shields are very thin, and the surface of the shell is marked with a faint vermiculate sculpture. We are thus led on to the European *Trachyaspis*, which is probably an allied form, and with which one or other of the American types may perhaps prove to be identical. This genus, which has elongated vertebral shields recalling those of *Dermatemys* and *Baptemys*, occurs typically in the European Tertiary, and has also been recorded from the Lower Greensand of Switzerland, although the latter form has been referred by Professor Rütimeyer to *Plesiochelys*. A nearly entire carapace has also been obtained from the Tertiary of Egypt. Th[...] surface of the shell is covered with a distinct vermiculated sculptur[...] like that of *Trionyx*, but thin epidermal shields were present.

FAMILY PLATYSTERNIDÆ.—The existing Burmese genus *Plat*[...] *sternum* is represented by a very small Chelonian forming the on[...] member of a family which connects the *Chelydridæ* with the *Test*[...] *dinidæ*. Thus the temporal fossæ of the skull are roofed over, t[...] pelvis is of a Chelydroid type, and the caudal vertebræ are most[...] opisthocœlous; but the nuchal agrees with that of the *Testudini*[...] in having no costiform process.

LY TESTUDINIDÆ.—Following Mr Boulenger's arrangement, ensive family is taken to include the *Cistudinidæ* and most *Emydidæ* of other writers, and may be briefly characterised ws: The limbs terminate in free digits; epidermal horny are always present, but there is no intergular shield; the e is ovoid and fully ossified; the plastron in the adult is ted with the carapace either by suture or a straight articula-nd is always fully ossified. There is no costiform process to chal bone; the temporal fossæ of the skull are not roofed y bone; the caudal vertebræ are procœlous; and the pubis hium of either side unite to enclose an obturator foramen. umerus has a well-developed head, and its shaft is more or rved. The skull is of nearly equal width throughout its post-portion. The Terrapins and Tortoises, as the existing mem-f this family are commonly termed, exhibit great variety of some being aquatic and others terrestrial; while some, again, rnivorous and others herbivorous. Some of the terrestrial have the normal two epidermal caudal shields of the carapace ogether into a single large shield.

may commence our brief survey of this large family with the al group of Batagurs, represented by *Batagur*, *Kachuga*, *Har-* and allied types. These include freshwater Terrapins, fre-y of large size, characterised by the great development of the and inguinal buttresses of the plastron, which divide the of the carapace into chambers, and also by the presence of more strong ridges on the oral surface of the palate, running l to its alveolar borders. On the plastron (fig. 1016) the between the humeral and pectoral shields is below the ento-l. *Kachuga* (including *Pangshura*) has the fourth vertebral elongated, and overlying parts of four or five neural bones; terior neurals being elongated and hexagonal, with the short nterior. The typical *K. lineata*, in which the fourth vertebral is broad anteriorly, is represented in the Pliocene Siwaliks of which also yield the existing *K. dhongoka*. In a second (*Pangshura*), in which the fourth vertebral shield is narrowed oint at its junction with the third, we have the existing *K.* (fig. 1016) in the Pleistocene and Pliocene of India. *Har-* fig. 1017) is characterised by the shortness of the fourth al shield, which usually extends over three neural bones n the figure), and by the third vertebral shield overlying of three (in place of two) neurals. It is represented in the s by the existing *H. Thurgi* (fig. 1017). With the exist-nerican genus *Chrysemys* we come to forms in which the and inguinal buttresses are much less developed than in tagurs, and the neural bones are shorter than in *Hardella*.

In *Chrysemys* itself the sulcus between the humeral and pec shields of the plastron is situated entirely on the hyoplastral, fig. 1016; and from the presence of this feature, it is prob that the so-called *Emys testudiniformis* and *E. bicarinata*, of London Clay, should be ferred to this genus. In existing genus *Ocadia*, China, and also in the P arctic and North Amer *Clemmys*, the humeropec sulcus is placed some more anteriorly, and co quently cuts the entopla bone. A similar feature frequently found in the called *Emys crassa* (*hord liensis*), of the Upper Eoce of Hampshire; and it a pears that this form sho be referred to the gen *Palæochelys*, of the Germ Miocene, from which *Oca* is probably not separabl *Emys wyomingensis*, of the Upper Eocene of North America, appears to be re ferable to the same genus *Ocadia*, it may be observed, agrees with the herbivorous Batagurs in the presence of ridges on the palate; but these ridges are absent in *Clemmys* and the undermentioned forms, which are purely carnivorous.

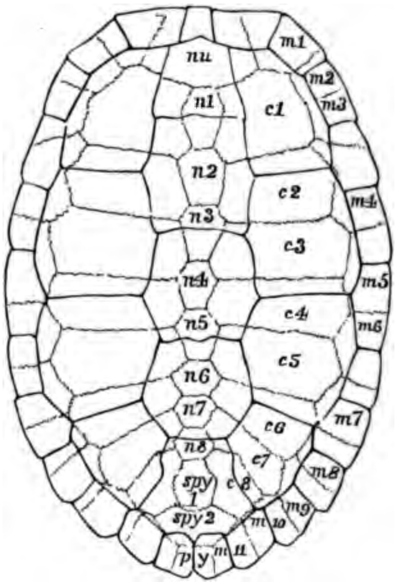


Fig. 1017.—Carapace of *Hardella Thurgi*; India. *nu*, Nuchal bone; *n1–n8*, Neural do.; *spy*, Supra-pygal do.; *py*, Pygal do.; *c1–c8*, Costal do.; *m1–m11*, Marginal do. Reduced.

These forms may be divided into two groups, according as to whether the plastron is united to the carapace by suture, or simply by ligament. In the former series *Clemmys* is represented in the Pliocene of Algeria by a species closely allied to the existing *C. leprosa* of that region. The characteristic Oriental genera *Damonia* and *Bellia* are represented in the Pliocene Siwaliks of India; the fossil *Damonia* being apparently inseparable from the living *D. Hamiltoni*. In the second series, where there is a more or les complete transverse hinge in the plastron at the junction of th hyo- and hypoplastrals, and the buttresses of the carapace may b wanting, we find remains of the existing *Emys orbicularis* (*E. l traria* or *Lutremys*), commonly known as the European Pond-to toise, in the Pleistocene of England and the Continent. *Cistud* is almost exclusively terrestrial, has been recorded from the ental Miocene. The Indian genus *Nicoria*, which is repre- by the existing *N.* (*Chaibassia*) *tricarinata* in the Siwaliks, is uished from all the preceding forms in that the neural bones ıeir short side placed posteriorly. The extinct *Ptychogaster*, of wer Miocene (Upper Oligocene) of France, is characterised by amentous junction of the hypoplastral with the carapace, and presence of a hinge between the hypo- and hyoplastrals, and the contour of the neural and costal bones, which approxi- o those of the true Tortoises; from which we may assume is form was mainly of terrestrial habits. In both genera the o-pectoral sulcus cuts the entoplastral bone.

he land Tortoises, forming the last group of the family, the bones are generally very short and wide, and may be either nal, or alternately tetragonal and octagonal; while the costal are generally alternately short and long at their inner and extremities; the suture between the marginal and costal bones coincides with the sulcus dividing the corresponding shields, e caudal shield is generally undivided. In most cases the between the humeral and pectoral shields is behind the ento- l bone. The digits differ from those of most of the preceding by being adapted solely for walking, and devoid of webs; the metacarpals are shorter, and the humerus is very much , with its radial and ulnar processes approximated. The least ised existing forms are *Cynixis* and *Pyxis*, which have neural like those of *Homopus*, but costals of the ordinary Emydine they appear to be unknown as fossils. *Hadrianus*, of the (Bridger) Eocene of the United States, includes generalised ses of large size, in which the neural bones are elongated and nal, with the shorter lateral surfaces posterior; the costals do ternate in length; the vertebral shields are narrow; and the shield is divided. The genus *Homopus*, which now includes species of small size confined to Africa, has no ridge on the and the neural bones are short and hexagonal, with short o-lateral surfaces, and the caudal shield is single. It is repre- in the Upper Miocene of Switzerland by the so-called *Emys* ı, and in the London Clay by *E. Comptoni*. In *Stylemys*, from hite River Miocene of the United States, the short neural bones ıeir shorter lateral surface placed anteriorly, the posterior costals t alternate in length at their extremities, and there is a single shield. All the remaining forms may be included in *Testudo*, ch the palate has one or two ridges; the neural bones usually of an alternation of small tetragonal and larger octagonal while the anterior extremity of the epiplastrals is more or ickened. In the skull the pterygoids are wide, and depressed in the middle (fig. 1017 *bis*). Usually the caudal shield is si but it may be divided. The ribs have no heads for articulation the vertebræ. The forms described as ***Manuria*** and ***Colosso*** may be included in this genus, which comprises a large numbe species. Exclusive of the Jurassic so-called *T. Stricklandi*, w has been already mentioned under the head of ***Protochelys***, earliest occurrence of the genus appears to be in the Upper Eoce Phosphorites of France; it is, however, not certain that the fo from these deposits may not be referable to one of the Americ genera. A marginal in the British Museum indicates an individ about 30 inches in length. *T. gigas*, of the Miocene of Hau Loire, is a still larger form; and species of large dimensions al occur in the Lower Miocene of Allier and the Middle Miocene Gers, as well as in the Pliocene of France and Greece.

The huge *T.* (*Colossochelys*) *atlas*, of the Pliocene Siwaliks of Indi was one of the earliest of the large extinct forms brought to the notic of science, although its size has been greatly exaggerated. It appear indeed, that the length of the carapace was about six feet, or one-thir greater than in *T. elephantina*, of the Galapagos Islands. This specie is remarkable for the great development of the epiplastral bones, which formed a pair of horn-like processes; and is also noteworthy for the anchylosis of the three bones of the pelvis into an innominate bone. The skull, which probably belongs to this species, resembles in structure the skulls of the recent giant tortoises of Aldabra. The carapace had no nuchal shield, the caudal shield was divided, and the limbs were covered with bony ossicles, as in the existing *T. emys* of India, to which this form was probably allied. The large *T. perpiniana*, of the Pliocene of France, in which the depressed carapace measures nearly four feet in length, and the limbs were likewise covered with dermal ossicles, was probably also nearly allied. An unnamed species, from the Pliocene of the Siwalik Hills, has a skull resembling that of the Galapagos tortoises (fig. 1017 *bis*); which are characterised by the backward extension of the opisthotics. We also find in the Siwaliks *T. Cautleyi* characterised by its small epiplastrals; and *T. punjabiensis*, which appears to have been a form allied to the smaller existing Indian *T. emys*. Remains of giant tortoises also occur in the Pleistocene cave-deposits of Malta.

Finally, we must not omit to briefly mention the giant tortoises of the present epoch, which, it appears, have been driven from the continental areas by the competition of the higher types of life to seek refuge in islands, where they attained an extraordinary numerical development, till their haunts were invaded by man. These tortoises formerly existed in great numbers in the islands of the Aldabra group, lying to the north-west of Madagascar; in the Mascarenes, which comprise Mauritius and Rodriguez; and also in the Galapagos, or "Tortoise-Islands," which lie off the coast of South America. The Aldabra Tortoises are characterised by their deeply excavated palate, short opisthotics, and the presence of a nuchal and of double gular shields. Some of them were living in the year 1877. In the Pleistocene of Madagascar remains of two very large species have been found, both of which present the characters of the Aldabra forms. The Mascarene species have no nuchal shield, and only a single gular; and the whole of them have been exterminated by human cy. Their skulls resemble those of the next group (fig. 1017 *bis*) in ight excavation of the palate, and the produced opisthotics. Finally, Galapagos tortoises, a considerable number of which were found in marle and Abingdon Islands during the voyage of the Challenger, listinguished by the double gulars and the absence of the nuchal d. From the Pleistocene of South America, Dr Moreno describes large tortoises allied to the Galapagos forms; one of them being

1017 *bis*.—Palatal aspect of the cranium of *Testudo microphyes*; from the Galapagos . Two-thirds natural size. *au*, Auditory aperture; *bo*, Basioccipital; *bs*, Basisphenoid; ndyle of quadrate; *mx*, Maxilla; *oc*, Occipital condyle; *op*, Opisthotic; *pal*, Palatine; Premaxilla; *pt*, Pterygoid; *qu*, Quadrate; *squ*, Squamosal; *sup*, Supraoccipital spine; mer.

ribed as the probable ancestor of *T. nigra* (*elephantopus*) of the group. The carapace of *T. elephantina* measures four feet in a ght line.

AMILY CHELONIDÆ.—The last family of the Cryptodira differs all the preceding in having the limbs modified into more or complete paddles or flippers (fig. 1018), which in the existing s have only one or two claws. The carapace is broad and or less depressed, and is very generally heart-shaped (fig.), although in some of the early forms it is rounded at both mities. The nuchal bone has no costiform process; there are lly larger or smaller unossified spaces between the costals and inals of the carapace (fig. 1006), but in very old individuals may obliterate in some forms; and the plastron is not articulated to the carapace, and has digitated lateral terminations, and generally a larger or smaller median vacuity (fig. 1009). The humerus is more or less flattened, with the axis of the head generally placed nearly immediately above that of the shaft, and the radial process small, and placed more or less below the well-developed head. The caudal vertebræ are procœlous, and the cervicals extremely short. In the skull the temporal fossæ are completely roofed over by bone, so that the squamosal joins the parietal; and the bones of the palate unite for a longer or shorter distance beneath the narial passage, so as to throw the posterior nares more or less backward (fig. 1020). The prefrontals (as in most *Testudinidæ*) always form a re-entering angle posteriorly; and the tympanic cavity is quite open posteriorly, so as to expose the stapes. In old individuals the vacuities in the shell tend to ob-

Fig. 1018.—Young of the Hawksbill Turtle (*Chelone imbricata*). Much reduced. (After Bell.)

literate, and in the more generalised extinct types this tendency is much more marked, and it is quite probable that in some cases they may have completely disappeared. This more complete ossification of the shell in these generalised types indicates affinity with the preceding families, and probably more especially with the *Acichelyidæ;* and the same is indicated by other features, such as the more marked constriction of the shaft of the humerus, and the more oblique position of its head, together with the probable presence of claws to all the digits. Some writers, indeed, consider these more generalised types as entitled to constitute a distinct family—the *Propleuridæ;* but their close relationship to the existing Logrhead forbids this view. We have already suggested reasons for garding this family as being descended from the Mesozoic *Aci-elyidæ*, and from this point of view it is interesting to note the esence of an intergular shield in the plastron of the existing, and obably, therefore, of the fossil forms, since, as we have already ated, this appears to be an archaic feature. The same observa-on will apply to the open tympanic ring. At the present day ere are four living species of Turtles — viz., the Loggerhead *halassochelys caretta*, fig. 1006), the Mexican Loggerhead (*T. empi*), the Hawksbill (*Chelone imbricata*, fig. 1018), and the reen Turtle (*C. mydas*), all of which are of purely marine habits. he Hawksbill alone is carnivorous; and is further peculiar for the rcumstance that in the young state the epidermal shields imbricate, stead of uniting by their edges. It has been suggested that the xtinct genera were of estuarine rather than purely marine habits; nd this is borne out by their occurrence in the estuarine deposits f the London Clay, to the exclusion of the marine genus *helone*.

The most remarkable of the extinct genera is *Lytoloma* (*Euclastes*, *uppigerus*, *Glossochelys*, or *Erquelinnesia*), which occurs typically n the Eocene of North America and the London Clay, and is also epresented in the Middle Eocene of Bracklesham, as well as in the halk and Cambridge Greensand. In the typical Eocene forms, ke the so-called *Chelone planimentum* and *C. crassicostatum* of the ondon Clay, the skull is as large in proportion to the shell, as in *Macroclemmys* among the *Chelydridæ*. The skull of the adult is emarkable for the extremely backward position of the posterior nares, which are approximated to the basioccipital; and for the length and width of the mandibular symphysis (fig. 1019, A). The palate has low alveolar walls, and no oral ridge; the nares and orbits are directed somewhat upwardly; and the bar between the latter is narrow. The shell is characterised by the great extent of its ossification, as well as by the rounded posterior extremity of the carapace, and the sutural connection of the broad xiphiplastrals in the median line. The head of the humerus is somewhat oblique, and its shaft much constricted. The limbs were clawed. Curiously enough, in the young, and perhaps also in the adult of some of the smaller forms, the posterior nares were placed much less back-wardly, and the mandibular symphysis was shorter and less flattened. It is probable that at least some of the North American Eocene forms described as *Osteopygis*, *Propleura*, and *Catapleura*, are not separable from this genus; while a turtle from the Creta-ceous of Australia, originally described by the preoccupied name of *Notochelys*, but which has been provisionally designated *Noto-helone*, is probably also nearly related.

Closely allied to the preceding is the genus *Thalassoche*
represented by the Loggerhead (fig. 1006). The skull is, ho
relatively smaller in proportion to the shell, which is disting
by the presence of five costal shields; the carapace is heart-sh
the xiphiplastrals are narrow, and join only at their extrem
while the terminal phalangeals are flattened and have but o
two claws. The shell is distinguished from that of *Chelone*
more complete ossification, and its T-shaped entoplastral;

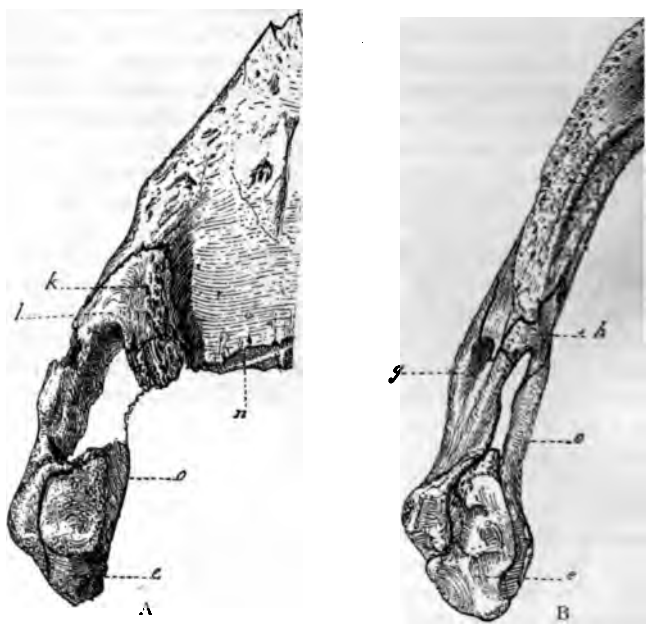


Fig. 1019.—Oral aspect of the left half of the mandible of *Lytoloma crassicostatum*
Chelone mydas (B). Reduced. The former from the Lower Eocene of Belgium, the l
cent. *c*, Postarticular process; *o*, Splenial; *n*, Geniohyoid groove; *g*, *k*, Insertion of t
muscle; *h*, Coronoid process.

the humerus is more constricted, and has its head placed
obliquely. The position of the posterior nares and the form o
palatal walls and mandibular symphysis closely resemble the
parts in the young of *Lytoloma*. In very old specimens the
ties between the costals and marginals completely close up.
genus probably occurs in the London Clay,[1] and also in the M
Eocene of Bracklesham.

[1] As indicated by a mandibular symphysis in the British Museum.

In *Argillochelys*, of the London Clay, the skull (fig. 1020), which is very short and has deeply emarginate pterygoids, differs from that of the preceding genera by the presence of an oral ridge on either side of the palate and in the middle of the mandibular symphysis, although these are present in the Mexican Loggerhead. The vomer, as in the young of *Lytoloma*, is very long, and extends forwards to join the premaxillæ; and the pterygoids are characterised by the forward position of their ectopterygoid processes. The shell seems to have been much like that of *Thalassochelys*, but had only four costal shields, and its plastron was perhaps

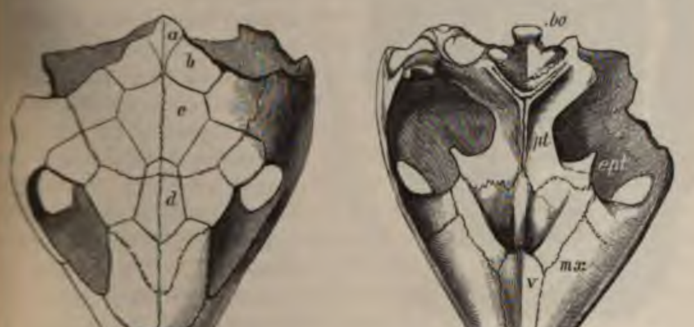


Fig. 1020.—Frontal and palatal aspects of a young cranium of *Argillochelys cuneiceps*; from the London Clay. Owing to immaturity the palatal ridges are imperfectly developed. *a*, Occipital, *b*, Paroccipital, *c*, Parietal, and *d*, Frontal epidermal shields; *bo*, Basioccipital; *pt*, Pterygoid; *ept*, Ectopterygoid process of do.; *v*, Vomer; *mx*, Maxilla; *pmx*, Premaxilla. The crosses on the frontal aspect correspond with those of fig. 1022, in which letters are given.

less ossified, although the xiphiplastrals united extensively in the middle line. The mandibular symphysis is convex, and comparatively short. The skull of the type species was originally described as *Chelone cuneiceps*; while the shells figured as *C. subcristata* and *C. convexa* are referable to this genus.

In the typical genus *Chelone* the skull is much smaller in proportion to the shell than in *Thalassochelys*. It is characterised by the more or less nearly vertical position of the nares and orbits, and the width of the bar between the latter; by the tall alveolar walls and the oral ridges of the palate and mandibular symphysis; the long pterygoids, with the ectopterygoid processes placed somewhat backwardly; the forward position of the posterior nares; and the more or less marked shortness of the convex mandibular symphysis (fig. 1019, B). The skull, moreover, has no occipital epidermal shield, which is generally present in the other forms (fig. 1020). In the shell the carapace is either heart-shaped, or pointed at ea (fig. 1021); the vacuities are large and persistent; the ento is long and dagger-s and the xiphiplastra slender and separat 1009). The humerus little constricted, with it nearly on the axis of the and the coracoid is long more slender than in sochelys; the Green Tu mydas) being more spec in these respects tha Hawksbill (fig. 1018). earliest occurrence o genus appears to be Cambridge Greensand Gault, where *C. Jessoni* very massive mandible, what resembling that Hawksbill. This form possibly be identical v *Benstedi* of the Chal 1021), which is only de known by very young and has been made the type of the genus *Cimoliochelys.* topmost Cretaceous of Maastricht the gigantic *C. Hoffma* pears to be allied to *C. imbricata*, but has a shorter and palate and mandibular symphysis, a more deeply emarginate and the costal bones extremely short. From the latter very ised character Dr Baur regards this species as entitled to distinction, and has proposed the name of *Allopleuron*. An large, and perhaps closely allied turtle occurs in the English In the higher Miocene of Bordeaux *C. girondica* appears t form closely allied to existing types.

Fig. 1021.—Carapace of *Chelone* (?) *Benstedi*; from the English Chalk. Reduced. (After Owen.)

SECTION 4. TRIONYCHOIDEA.—The last section of the su includes the mud-turtles or soft-tortoises, of the freshwaters c Africa, and North America; all of which are of aquatic a nivorous habits. These forms, which may probably be re as extremely specialised types, present the following dis features. The shell is sculptured and devoid of epidermal s its entoplastral being in the form of a chevron, which divi epiplastral from the hyoplastral; and the marginals, if p forming only an incomplete series at the posterior extremity carapace, and having no connection with the ribs. The lo vertebræ have no distinct transverse processes, and the eighth ulates with the first dorsal solely by the zygapophyses, thus ing the most remarkably complete hinge-joint among the whole e Vertebrata. The fourth digit in each limb is characterised by ng not less than four phalangeals. The form of the tympanic of the quadrate, and the relations of the latter to the mandible, of the same type as in the Cryptodira; and we find a similar nce of union between the pelvis and the plastron. In the ium (fig. 1022) the chief distinctive features are to be found in palate; thus the broad pterygoids are separated from one another the basisphenoid, which extends forwards to join the palatines; latter, owing to the small size of the vomer, uniting extensively he middle line; and the whole structure of the palate being of a urodiran type. As minor characters of the skull, attention may directed to the open temporal fossæ, and the forward position upward direction of the small orbits, as well as to the extreme elopment of the backward processes of the supraoccipital and amosal. The sacral and caudal ribs articulate only with the ches of the vertebræ, and there are no chevrons. The plastron is ways entirely separate from the carapace, and has a large median acuity and digitate extremities, as in the marine *Chelonidæ*. Further, the head and neck are retracted within the carapace after the Cryptodiran manner, but, owing to the peculiar structure of the eighth cervical vertebra, in a still more complete way. In all cases the posterior lateral surfaces of the neural bones of the carapace are much shorter than the anterior.

The marked resemblance of the palate and the general aspect of the Trionychoid skull to that of existing Pleurodira is a circumstance that does not admit of a ready explanation from a phylogenetic point of view, unless we adopt the somewhat improbable suggestion that the Pleurodira gave origin to the Trionychoidea at a time when their pterygoids had attained their full width, but while the tympanic ring was still partially open.

FAMILY TRIONYCHIDÆ.—The whole of the members of this section may be included in a single family, which is, however, susceptible of division into two subfamilies. In the first, or *Emydinæ*, the opisthotic of the skull unites with the pterygoid to divide the posterior aperture of the auditory labyrinth into two foramina; the hyo- and hypoplastral of either side are fused together; the sculpture of the carapace is tuberculated; and marginals may be present. The existing Oriental genus *Emyda*, in which marginals and a complete series of neurals are present, is represented by numerous species in the Pliocene Siwaliks of India, some of which attained very large dimensions. The African genera *Cyclanorbis* and *Cycloderma*, in which marginals were not developed, are at present unknown in a

fossil state. In the second subfamily, or *Trionychinæ*, the hy
hypoplastrals remain distinct throughout life; the pterygoi
not join the opisthotic behind the labyrinth; the sculpture
consists of sinuous ridges or pits; and marginal bones are
developed in the carapace. The type genus *Trionyx* is wid
tributed at the present da
extends downwards into the
Eocene of both Europe a
United States, and is also
sented in the Upper Cretac
the latter area. Many spec
remarkable for showing din
types of skull, which in one
fication has a broad palate a
for crushing, while in the ot
palate is very narrow. The
species, in which the skulls
subject to this variation, ha
short neural bones between t
costals; while in the recent
can forms there are but seve
of costals. All the Europea
forms agree with the majo
species in having only one
neural bone between the fi
tals. In Europe this genus a
to be unknown above the
Miocene of Œningen, and i
tremely abundant in the
Eocene (Lower Oligocene) of
well. The existing Indian
occur in the Pleistocene an
cene of that country. Of the American Tertiary species a
some have eight costals, and in some cases only six neurals.
Lower Eocene and Upper Cretaceous forms described by Pr
Cope as *Plastomenus* may be included in the type genus, sin
thickening of the plastron can scarcely be regarded as a g
character. The same remark applies to the Eocene *Axestus*,
United States, in which the plastron is smooth, as in some e
forms. An apparently distinct type, in which the outer mar
the costals is deeply grooved, occurs, however, in the E
Upper Eocene, which has been named *Aulacochelys*. Final
exclusively Oriental genus *Chitra* is represented in the Pl
and Pleistocene of India by remains of the one existing spec
indica, the largest member of the family.

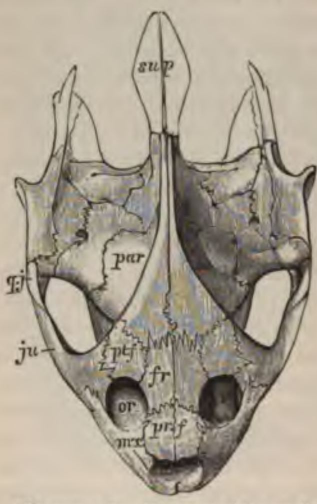


Fig. 1022.—Frontal aspect of the cranium of *Trionyx gangeticus*; from the Pleistocene of India. Reduced. *sup*, Supraoccipital; *par*, Parietal; *pt.f*, Postfrontal; *fr*, Frontal; *pr.f*, Prefrontal + nasal; *mx*, Maxilla; *ju*, Jugal; *q.j*, Quadratojugal; *or*, Orbit. The processes on either side of the supraoccipital are formed externally by the squamosal, and internally by the opisthotic, of which the inner border articulates with the supraoccipital; externally to the parietal is the proötic.

CHAPTER LIV.

CLASS REPTILIA — continued.

[OR]DERS ICHTHYOPTERYGIA, PROTEROSAURIA, RHYNCHOCEPHALIA, AND SQUAMATA.

[STRE]PTOSTYLIC BRANCH. — According to the arrangement pro[pose]d by Dr Baur, this branch is taken to include the four orders [men]tioned in the heading of this chapter. These orders present a [rema]rkable instance of the divergent views obtaining among different [write]rs as to the classification of Reptiles. Thus Professor Cope [has] proposed to place the Ichthyopterygia in a group by themselves, [whic]h he regards as of equal value to another containing all the [othe]r orders; while Professor Seeley at one time regarded this order [as a] division of the Dinosauria, although its relationship to the [Squa]mata had been long before pointed out by Sir R. Owen. Pro[fesso]r Seeley has also proposed to separate the Squamata from all [othe]r Reptiles under the name of Cœnosauria, and to include the [Rhy]nchocephalia in a second division as Palæosauria. Professor [Cop]e, while not going so far as this, places the Rhynchocephalia in [his] Synaptosaurian branch; while Professor Huxley would include [bot]h that group and the Proterosauria in the Squamata (Lacertilia), [fro]m which the Ophidia are excluded. Dr Baur, again, merges the [Prot]erosauria in the Rhynchocephalia, and regards the latter as a [disti]nct order allied to the Squamata. This middle course is fol[lowe]d in the present work, although the Proterosauria, in accordance [with] the views of Professor Seeley, are provisionally allowed to rank [as a]n order.

[T]he present branch may be collectively characterised as follows: [The] dentition is very generally either acrodont or pleurodont, with [the t]eeth of the adult anchylosed to the jaws; but the teeth may [be i]mplanted in a groove, and remain free. In addition to their [prese]nce in the jaws, teeth may also be developed on the palatine [and] pterygoid, and very rarely on the vomer. There is very frequently a parietal foramen; the superior temporal arcade is g ally present, but in the more specialised forms the inferior is wanting. The quadrate may be either movably or immo attached by its proximal extremity to the cranium; a colume very generally present; and the ramus of the mandible never a lateral vacuity. The precoracoid appears to be fused with coracoid, and may be represented by a precoracoidal process 1040), or its position indicated merely by a fontanelle, while in Ichthyopterygia even the latter is wanting. A T-shaped interclavi and clavicles are present in all the earlier and a large proportion the later forms. Usually all, or nearly all, of the dorsal ribs arti late by single heads; the dorsal vertebræ either have short or rud mental transverse processes, which are never placed entirely on arch, or (Ichthyopterygia) a pair of facets on the centrum; and with one exception, there are not more than two vertebræ in sacrum. Abdominal ribs are present in the earlier, but are lost most of the later forms. The humerus frequently has an ectepico dylar foramen. The number of phalangeals in the digits of pent dactylate land forms is generally 2, 3, 4, 5, 3, in the manus, a 2, 3, 4, 5, 4 in the pes.

In no case are secondary posterior nares formed by the develo ment of plates from the bones of the palate to floor the nasi passage; the posterior nares consequently always forming more less slit-like horizontal apertures in the roof of the mouth. Neithe is the posterior extremity of the palate ever completely closed b the junction of the pterygoids with the basisphenoid, after th fashion obtaining in the Chelonia (fig. 1017 *bis*) and some Sauro pterygia; there being always a vacuity between the hinder extrem ities of the pterygoids which displays the presphenoidal rostrum.

Order IV. Ichthyopterygia.—The Mesozoic Ichthyosaurs and their allies were large marine Reptiles, with the body long, and shaped somewhat like that of the Cetacea (fig. 1023), without

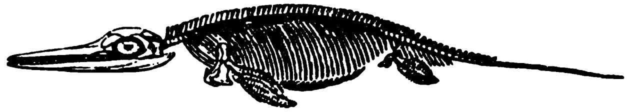
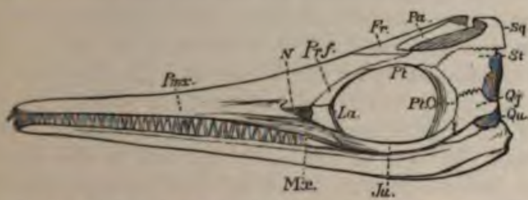


Fig. 1023.—Greatly reduced restoration of the skeleton of *Ichthyosaurus communis*; from t Lower Lias of Dorsetshire. The pelvic limb is relatively too large. (After Owen.)

either dermal or epidermal skeleton; the limbs being modified in paddles, in which the component bones were in apposition on sides, and the phalangeals were oval or polygonal, and increas beyond the normal number. The skull (fig. 1024) has the fac region produced into a long rostrum, mainly formed by the p llæ in the upper jaw; and the nares are consequently approxi-ed to the orbit, which is of very large size, and has a ring of plates in the sclerotic; there is a large parietal foramen; and re are two temporal arcades connected together by the supra-mporal (prosquamosal or supraquadrate), which roofs over the temporal fossa, after the Labyrinthodont fashion. Other char-



ig. 1004.—Reduced left lateral view of the skull of *Ichthyosaurus intermedius*; from the wer Lias of Dorsetshire. *Pmx*, Premaxilla; *Mx*, Maxilla; *N*, Nares; *La*, Lachrymal; *f*, Prefrontal; *Fr*, Frontal; *Pa*, Parietal; *Pt*, Postfrontal; *St*, Supratemporal; *Sq*, Squa-al; *Qj*, Quadratojugal; *Qu*, Quadrate; *Ju*, Jugal; *Pt.O*, Postorbital. (After Huxley.)

teristic features of the skull are the small frontals; the presence f an opisthotic in the occipital region; the distinctness of the post-rbital from the postfrontal, and of the lachrymal from the pre-ontal; the firm fixture of the quadrate, which does not, however, uturally unite with the pterygoid; and the presence of a foramen eparating the middle portion of the quadratojugal from that bone, as

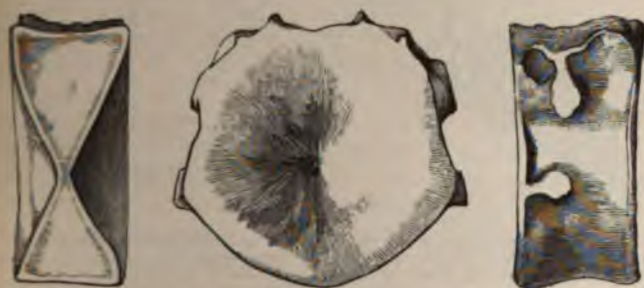


Fig. 1005.—The centrum of an anterior dorsal vertebra of *Ichthyosaurus*, viewed in section, and from the anterior and left lateral aspects; from the Kimeridge Clay of Wiltshire. Reduced. (After Owen.)

n the existing Rhynchocephalian genus *Sphenodon*, and the presence f a columella, or epipterygoid. The palate has essentially the same tructure as in the last-named genus. As in the Squamata, there is o lateral vacuity in the mandibular rami. The teeth are confined to e jaws, and are implanted in a continuous groove, without anchy-sis to the bone. Their crowns are sharply pointed, and are usually cylindrical and deeply fluted (fig. 1032), but are occasionally pressed, carinated, and smooth (fig. 1028). The vertebral co is primarily divisible only into a precaudal and a caudal s there being no sacrum. The centra (fig. 1025) are amphico more or less disk-like, and either deeply cupped or nearly flat. either side those of the precaudal series (fig. 1025) carry a pai tubercles for the articulation of the double-headed ribs; while in caudal region these tubercles coalesce. Superiorly each centrum h pair of flattened surfaces for the attachment of the neural arc which are united merely by synchondrosis. In the cervical re the tubercles for the ribs are placed near the summit of the lat surfaces of the centra, and they gradually descend on the centr till they reach the base of the lateral surface in the posterior p caudal and caudal regions. In some forms the upper costal tube of the anterior vertebræ is placed either partly or entirely on t neural arch, and it is convenient to term such vertebræ, or th homologues, cervicals, and the remainder of the precaudal ser dorsals. The centrum of the atlas vertebra is well developed, a

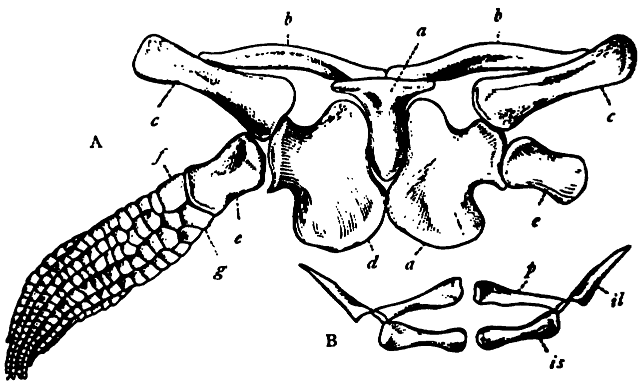


Fig. 1026.—A, Ventral aspect of the pectoral girdle and right limb of *Ichthyosaurus int medius.* B, Pelvic girdle of do. Reduced. *a*, Interclavicle; *b*, Clavicle; *c*, Scapula; Coracoid; *e*, Humerus; *f*, Ulna; *g*, Radius; *il*, Ilium; *is*, Ischium; *p*, Pubis. (Af Huxley.)

there is a large intercentum between the atlas and the skull, a another between the former and the axis. There was no sternun but a complex system of abdominal ribs was developed. T dorsal ribs were devoid of uncinate processes; and ribs occur the caudal region. In the pectoral girdle (fig. 1026, A) there no precoracoid; but clavicles and a T-shaped interclavicle, like t corresponding bones of the Lacertilia, were developed. The co coids were large and expanded, devoid of any fontanelle, and r lapping one another at their junction. The three bones of the s (fig. 1026, B) are weak and rod-like; the ilia have no con-ion with the sacral region of the vertebral column; and although pubis and ischium of opposite sides meet in the middle line, e of the same side do not unite to enclose the obturator notch. humerus and femur are relatively short; but the radius and a are still shorter, and may be reduced to oblong bones in ch the transverse diameter is the longer.

e humerus has no foramen. The struc-e of the paddles will be noticed under e head of the different genera; but it may e observed that when there is a difference n the size of the limbs it is the pectoral that is the larger. From the less special-ised structure of the limbs of the earlier forms Dr Baur regards the Ichthyopterygia as descendants of land animals; a conclu-sion which is supported by the argument that had these Reptiles originated directly from Fishes, as was formerly supposed to be the case, they would have retained their gills. In regarding this order as closely allied to *Sphenodon*, Dr Baur lays stress upon the general similarity in the cranial structure, and especially the presence of the foramen between the quadrate and quadratojugal; the identical structure of the abdominal ribs; and the remarkable similarity of the pectoral girdle, which, this author remarks, is only comparable to that of the existing genus, especially when young. In the skull and vertebral column the Ich-thyopterygia retain evidences of their Laby-rinthodont descent, which are lost in the other orders of this branch.

Fig. 1026 *bis.* — Proximal, dorsal, and distal aspects of the left humerus of *Ichthyosaurus;* from the Kimeridge Clay. One-third natural size. *a*, Trochanteric ridge; *r*, Facet for radius; *u*, Do. for ulna.

This order is known to range with cer-tainty from the Upper Trias to the Upper Chalk. It was also widely distributed in space; its remains having been discovered in the Arctic regions, in Europe, India, Ceram, North America, the east coast of Africa, Australia, and New Zealand. Part of a jaw referred to *Ichthyosaurus* has been de-scribed from Malta, which, it has been suggested, may be of Miocene age, but this requires confirmation.

It may be remarked that the humerus and femur of this order are quite unique in that, instead of having convex condyles for the

articulation of the epipodial bones, they present distinct conca
(fig. 1026 *bis*) for their reception.

FAMILY ICHTHYOSAURIDÆ.—Although Dr Baur makes the g
Mixosaurus, *Ichthyosaurus*, and *Opthalmosaurus* the types
many families, yet it seems on the whole more convenie
include all the known forms in a single family. The most ge
ised group with which we are at present acquainted is the g
Mixosaurus, from the Upper Trias of Italy, which is founded
a small species presenting the following characters. The hum
and femur articulate distally with two bones; and the radius
ulna are elongated, and separated from one another by an inter
throughout their entire length. The teeth are small, and not
cessively numerous. It may eventually prove that all the Trias
forms are referable to this genus. The ty
genus *Ichthyosaurus* is characterised by the u
presence of teeth throughout the jaws; and
the normal articulation of the humerus with o
the short radius and ulna, which are in close
position (fig. 1027). In the pelvic limb th
femur similarly articulates only with the tib
and fibula at its distal extremity; and thus th
extremity in both the humerus and femur has on
two articular facets (fig. 1026 *bis*). The bo
which articulates inferiorly with the radius an
ulna at their junction is the intermedium (fig.
1027, *i*); while the one filling up the angle be-
tween the latter and the radius is the radiale;
the opposite angle being occupied by the ulnare.
Below the intermedium we have the centrale,
which in the more specialised forms may be
double (fig. 1031), and below this the remain-
ing carpals, metacarpals, and phalangeals, which
are combined to form a pavement-like structure.
The bones forming the continuation of the line
of the intermedium in fig. 1027 correspond to
the middle or third digit of the typical manus;
and the structure of this limb indicates that it
was derived from a four-fingered ancestor, since the pollex, or first
digit, is not represented.

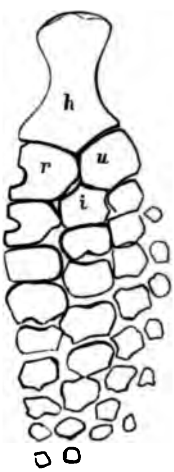


Fig. 1027. — Dorsal aspect of the left pectoral limb of *Ichthyosaurus latifrons*; from the Lower Lias. Reduced. *h*, Humerus; *r*, Radius; *u*, Ulna; *i*, Intermedium. (After Owen.)

Specimens have been obtained from the Lias of Würtemberg and Barrow-on-Soar, in Leicestershire, which show the contour of the integuments of the paddles. It appears from these that on the anterior border of the paddle (fig. 1027 *bis*) there was a comparatively narrow band of integument, which was covered by minute horny scales; while on the posterior border there was a much broader flap, which appears contained parallel bands of muscles set obliquely to the axis of ddle. In the Latipinnate group (fig. 1027 *bis*) the posterior flap gument was narrow in proportion to the bony framework of the and it was produced inferiorly into a long point below the distal In the Longipinnate group, however, the integuments were much in proportion to the bones, and they terminated inferiorly in a extremity, which only reached a short distance below the distal

larger forms attained a length of from thirty to forty feet; and it ght probable that the extremity of the tail was provided with a ranous fin. All the species were carnivorous; and, as we learn

1027 *bis*.—Part of the left pectoral limb of *Ichthyosaurus intermedius*, viewed from ural aspect, and showing the contour of the integument. One-half natural size. *hu*, Hu-; *r*, Radius; *u*, Ulna; *r'*, Radiale; *i*, Intermedium; *u'*, Ulnare; *c*, *c'*, Centralia. From wer Lias of Barrow-on-Soar.

the so-called coprolites, their food consisted to a considerable ex- of Ganoid Fishes. These coprolites further tell us that the intestine provided with a spiral valve, as in the Selachian fishes. Perhaps, ever, the most remarkable circumstance connected with their internal omy is the not unfrequent occurrence of entire skeletons of small iduals within the thoracic and abdominal cavity of larger ones; small specimens being invariably uninjured, and belonging to the species as the one in which they are contained. This leads Pro- r Seeley to conclude that some species or individuals were vivi- us, and that the young were probably produced of different relative in different species. There is also evidence to show that in some many young were produced at a birth; the number being perhaps ecific character. It cannot, however, be taken as proved that all yosaurs were viviparous, since in such other Sauropsida and Ich- psida in which the same mode of development occurs, it is not dis- ve of any entire group; and it is noteworthy that the three specimens with young figured by Professor Seeley all belong to a single This genus may be divided into two groups from the structur pectoral limb. In the *Longipinnate*, or least specialised group, unknown above the Lias, the orbit is generally of very large dim The pectoral limb (fig. 1027) is characterised by having the thi or that arising from the intermedium, comprising only a singl tudinal row of bones, and consequently having only one centrale there are usually only four longitudinal rows of phalangeals in th and the radius is nearly square, with a distinct notch in its border (fig. 1027). This group may be further subdivided int groups. One of the most aberrant forms is the huge *I. platyodon* Lower Lias, which attained of nearly forty feet. This sp characterised by the pelvic being nearly as large as the p but still more readily by th (fig. 1028), which have com carinated, and smooth crow the roots covered with a co cement. *I. lonchiodon* is a Lower Liassic form with cyl and fluted teeth. Another indicated by *I. tenuirostris latifrons* (*longirostris*), in wh cranial rostrum (fig. 1029) is elongated and very slender paddles (fig. 1027) are ren for the large size of the co bones; and in *I. tenuirostris* a small circular vacuity betw radius and ulna, indicating remnant of the large vacui in *Mixosaurus*. Lastly, *I. tris*, *I. zetlandicus*, and *I.* are three Upper Liassic mem this group indicating a tran the next group; the radius latter species having no anterior notch. The skull of *I. zetlan* shown in fig. 1030.

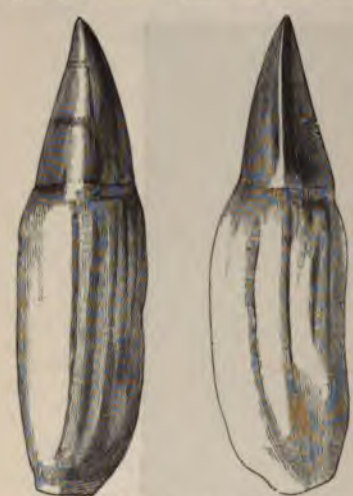


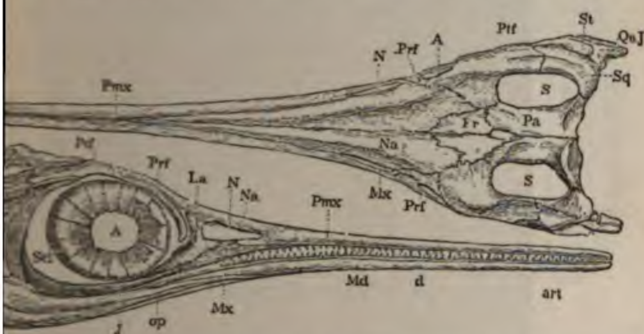
Fig. 1028.—Lateral and profile views of a tooth of *Ichthyosaurus platyodon*; from the Lower Lias of Dorsetshire.

In the more specialised or *Latipinnate* group, which ranges

Fig. 1029.—Left lateral view of the skull of *Ichthyosaurus latifrons*; from the Lo of Leicestershire. Reduced.

Lias to the Chalk, the orbit is usually relatively smaller than in group. The pectoral limb (fig. 1031) has the third digit, or tha from the intermedium, with a double longitudinal row of bones, a are consequently two centralia. There are, moreover, never l

udinal rows of phalangeals in this limb (the marginal rows are
n fig. 1031); and the radius is transversely elongated (and thus
ely removed from the normal type) with an entire anterior
It is important to observe that in this group the splitting of
digit and the two centralia are evidently acquired, and not
characters. Like the last, this group may be divided into
s. In the typical subgroup, which is confined to the Lias,
(fig. 1032) have their roots strongly fluted, and the dorsal
the humerus has no strongly-marked trochanteric ridge. *I.*



a.—Superior and right lateral aspects of the skull of *Ichthyosaurus setlandicus*; from Lias of Caen. Reduced. *Pmx*, Premaxilla; *Mx*, Maxilla; *N*, Nares; *Na*, Nasal; ymal; *Prf*, Prefrontal; *Fr*, Frontal; *Pa*, Parietal; *Ptf*, Postfrontal; *Sq*, Squamosal; emporal; *Por*, Postorbital; *QuJ*, Quadratojugal; *J*, Jugal; *A*, Orbit; *S*, Supra-ma; *Scl*, Sclerotic plates; *Md*, Mandible; *k*, Articular; *ang*, Angular; *op*, Splenial; r. (After Zittel.)

dius is the species least widely removed from the preceding
while the typical *I. communis* is distinguished by the extreme
f the paddles. In a second subgroup, which ranges from the
Clay to the Chalk, the roots of the teeth are invested with a
yer of cement; the dorsal aspect of the humerus has a pro-
trochanteric ridge; and the coracoid differs from that of the
ig subgroup (fig. 1026) by the absence of a posterior notch. This
p comprises *I. trigonus*, and probably other allied forms from
ord and Kimeridge Clays; and also the well-known *I. campylo-*
n the Upper Cretaceous of a large portion of Europe, to which
us, from the corresponding strata of India, and perhaps also *I.*
r, from the Cretaceous of Australia, are probably closely allied.
ner is in some respects even more specialised than the follow-
era. The species referred to this genus from the Polar regions
sidered to be of Triassic age; and a species from Ceram may
Cretaceous beds. The genus is unknown in America.

most specialised representatives of the family are the genera
nosaurus, from the Oxford and Kimeridge Clay and probably
e Cretaceous of England, and *Baptanodon* (*Sauranodon*),
e Upper Jurassic of North America. In the latter teeth,
n a dental groove, were totally wanting, but in the former
eeth were present. In the former (and probably also the

latter) the humerus (fig. 1033) and femur have a prominent anteric ridge, and in both they articulate distally with three di bones (figs. 1033-34), which in the pectoral limb are corr

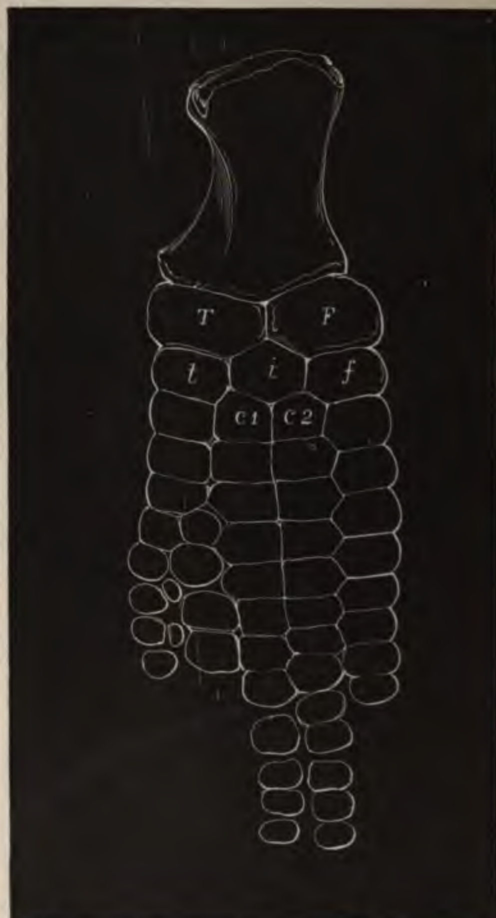


Fig. 1031.—Ventral aspect of the right pectoral limb (wanting the marginal rows) of *I saurus intermedius*; from the Lower Lias of Gloucestershire. Reduced. *T*, Radi Ulna; *t*, Radiale; *i*, Intermedium; *f*, Ulnare; *c1*, *c2*, Centralia. (After Hawki Hulke.)

by Dr Baur with the radius, ulna, and pisiform; the corres ing bones in the pelvic limb (fig. 1034) being the tibia, fibula the homologue of the pisiform. The clavicles differ from th *Ichthyosaurus* in being separate. Both limbs appear to have width, and the third digit, or the one arising from the ium, at least in the American genus, of two longitudinal rows of bones. e species of *Opthalmosaurus* was of size, and occurs in the Oxford and ge Clays; it is characterised by the y in the size of the three distal facets umerus. In *O. cantabrigiensis*, of the ge Greensand, which may belong to *don*, these three facets have, however, nearly equal in size; and this form herefore to indicate the highest evolu- the order. It should be mentioned fessor Marsh and Mr Hulke differ from r in their interpretation of the three f the second segment of the limb of us; correlating the middle bone with rmedium, and the postaxial one with in the pectoral, and the fibula in the imb. Finally, it should be observed femur, from the Cambridge Greensand, d under the name of *Cetarthrosaurus*, rded as belonging to a member of the present order, but as been referred by Mr Hulke to the suborder Pythono-

Fig. 1032.—Tooth of *Ichthyosaurus communis*; from the Lower Lias of Gloucestershire.

—Dorsal aspect of part of the right pectoral limb of *Opthalmosaurus icenicus*; from Clay. One-third natural size. *h*, Humerus; *a*, Trochanteric ridge of do.; *r*, Radius; Pisiform.

morpha of the Squamata, appears to approximate in struc the femur of *Ichthyosaurus campylodon*, and may therefor belong to this order.

ORDER V. PROTEROSAURIA.—The genus *Proterosaurus*, fr Middle Permian of Thuringia, is regarded by Professor Se presenting such peculiar features that it is entitled to ordi tinction, although Dr Baur would include it in the Rhynchoc

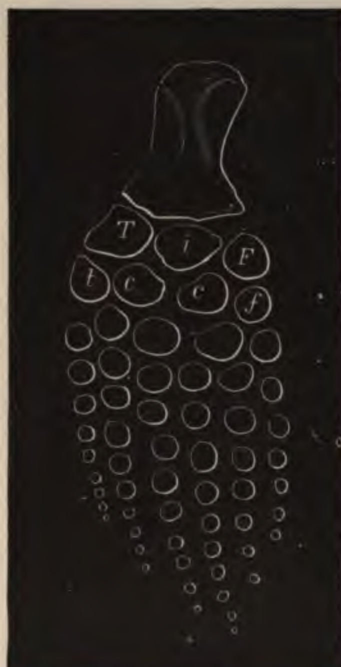


Fig. 1034.—Dorsal aspect of the left pelvic limb of *Baptanodon natans*; from the Upper Jurassic of North America. Reduced. *T*, Tibia; *i*, Fibula; *F*, Bone representing the pisiform of the manus; t_1 Tibiale; *c* (left side), Intermedium; *c* (right side), Fibulare; *f*, Undetermined bone. The two bones beneath the intermedium are the centralia. (After Marsh and Hulke.)

The skull is very imp known, and although P Seeley has attempted its tion, Professor Credner out that the specimens justify the figure. There doubt as to the mode of ment of the teeth to th but they appear to hav anchylosed to the bon cavities beneath them, an not, as has been su implanted in distinct Teeth also occur on th tine, pterygoid, and vom Professor Seeley conside the palate was closed. dorsal vertebræ are am ous, and have no inter but the cervicals appear been opisthocœlous, and markable for their length. were intercentra in the cervical region. In all tebræ the arches were anc to the centra; while in t sals the costal articula placed unusually high. posterior caudal vertebr divided neural spines. inal ribs were fully de (fig. 1035), and were ap of the Rhynchocephalian type. It has been suggested ilium may have had a preacetabular production; but the girdle seems to have been of the Rhynchocephalian ty clavicles and interclavicle, according to Dr Credner, closel bling those of *Sphenodon*.

According to Dr Baur there are two centralia in the

Professor Seeley describes a centrale (navicular) in the tarsus. ectoral limb is considerably shorter than the pelvic (left side 1035); and while both have five digits, neither presents any trongly marked divergence from the Rhynchocephalian plan acture. In the type species there were the normal two sacral ræ; but according to Professor Seeley, *P. Linki* differs from her known members of this branch in having three sacrals. highly probable that *Proterosaurus* should be regarded as a

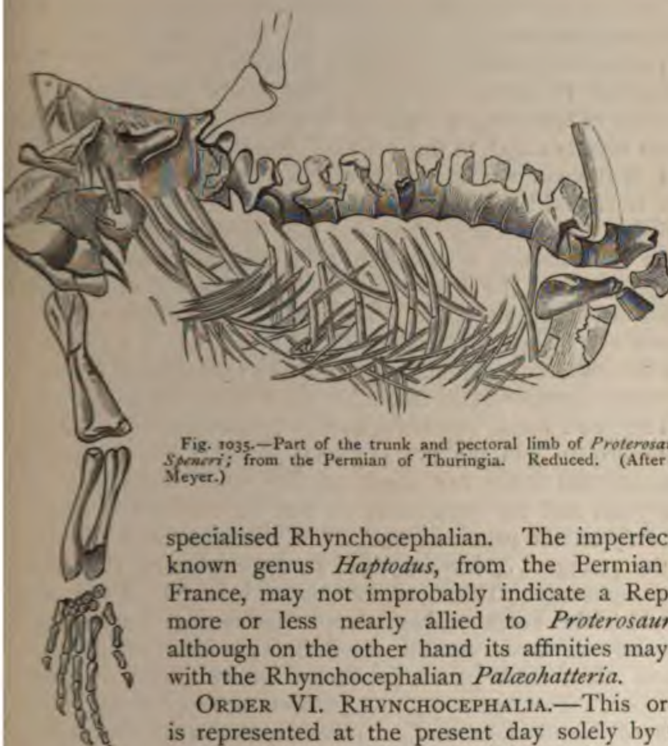


Fig. 1035.—Part of the trunk and pectoral limb of *Proterosaurus Speneri*; from the Permian of Thuringia. Reduced. (After von Meyer.)

specialised Rhynchocephalian. The imperfectly-known genus *Haptodus*, from the Permian of France, may not improbably indicate a Reptile more or less nearly allied to *Proterosaurus*, although on the other hand its affinities may be with the Rhynchocephalian *Palæohatteria*.

ORDER VI. RHYNCHOCEPHALIA.—This order is represented at the present day solely by the remarkable genus *Sphenodon* (*Hatteria*), and may be provisionally characterised as follows: The ernal appearance is usually more or less lizard-like. In the skull quadrate is immovably fixed by its proximal extremity, and tes by suture with the pterygoid; an inferior temporal arcade present (fig. 1039); the postorbital, at least in *Sphenodon*, is te distinct from the postfrontal; the palate is closed anteriorly the median union of the pterygoids, which, in the living form east, extend forwards to meet the vomers, and thus separate the palatines;[1] and the premaxillæ never united. The denti usually acrodont. The ribs may have uncinate processes, a dominal ribs are always developed. The vertebræ may be opisthocœlous or amphicœlous, and intercentra may be retai

Dr Baur observes that "the Rhynchocephalia, together w Proterosauria, to which they are closely allied, are certai most generalised group of all Reptiles, and come nearest, ir respects, to that order of Reptiles from which all others tool origin."

This order, if we include *Palæohatteria*, dates from the Pe but only comparatively few forms are at present known. l be provisionally divided into three suborders.

FAMILY PALÆOHATTERIIDÆ.—The genus *Palæohatteria*, Permian of Germany, is regarded by Professor Credner, its des as so closely allied to the existing *Sphenodon* that it is refer him to the same family. There can, however, be no questi that it is entitled to be the representative of a distinct famil probably of a distinct suborder. Dr Baur, with whom Pr Cope is in accord, would even go farther, and remove this altogether from the Rhynchocephalia, to place it with *Meso* in his order Proganosauria. There is, indeed, much to be favour of placing both these primitive Reptiles in a single but this appears to be outweighed by the resemblance of the the true Sauropterygians and of the other to the Rhynchocepl

The skull much resembles that of *Sphenodon*, the jugal d posteriorly to join the two temporal arcades; but the supr infratemporal fossæ are much smaller, while there is a s lachrymal, and the premaxillæ do not form a beak. Teetl not only on the palatines, but also on the vomer and pteryg in the young of *Sphenodon;* and Dr Baur suggests that th a parasphenoid. There are intercentra between all the ve in which the neural arches remain distinct from the centra are also two sacral vertebræ; and the ribs have no uncina cesses. The teeth of the jaws were acrodont, and anchyl the bone. The pectoral girdle presents an approximation, form of the clavicles and interclavicle, to that of *Sphenodo* the expanded proximal extremities of the clavicles recall the thoracic plates of the Labyrinthodonts, and the coracoid i like that of the Sauropterygians. This bone, indeed, like th of the pelvic girdle, ossifies by radiations from the centre af manner obtaining in Sauropterygians and Amphibians. The girdle is widely different from that of *Sphenodon;* the pub ischia forming wide flattened plates like those of the Sauropt

[1] The same arrangement obtains in the skull of *Nothosaurus*, repres fig. 991.

Mesosaurus, and the ischia being almost identical with those Amphibia. The tarsus also resembles that of *Mesosaurus* in five distinct bones in the distal row; while the humerus (as atter) has an entepicondylar, or ulnar, foramen.

Palæohatteria is a primitive type connecting the later Rhyn-halia with the Amphibia there can be no reasonable doubt; hough it presents many points of affinity with *Mesosaurus*, esemblances are those which we should expect to find in all onal types, and do not necessarily imply that all the forms in hey occur should be placed in the same group.

RDER I. SIMÆDOSAURIA.—This group is represented by the *Champsosaurus*, typically from the Lower Eocene of North a, which may be regarded as a somewhat specialised Rhyn-halian, showing a remarkable affinity, in the general structure skull and vertebral column, to *Hyperodapedon*. Dr Baur ob-that this genus agrees with the other Rhynchocephalia in the ondition of the otic bones, and in the nature of the costal tions; and since it has a fixed quadrate, two temporal ar- and abdominal ribs, there appears no good reason for its separation. The adaptation to an aquatic life has, however, rily produced considerable structural modifications of secon-port. The correctness of these observations has been re-ly shown by the researches of M. Dollo, who finds that the re of the palate, and the position of the posterior nares, and neral arrangement of the teeth, closely accords with that ng in *Hyperodapedon*. The suborder may be characterised ws: The facial portion of the skull is produced into a long n; the splenial bone enters into the mandibular symphysis; l and pelvic limbs are elongated; the vertebræ are amphi-; and the ribs have no uncinate processes.

ILY CHAMPSOSAURIDÆ.—In the type and only known family res are single and subterminal; the maxillary and anterior bular teeth are large and not fixed to the bone; there is a of smaller teeth on the palatines and vomers, separated by a from those of the maxilla; while there is also an irregular f small teeth on the pterygoids, which are completely united middle line; the posterior nares form very narrow slits on les of the palate; and there is no parietal foramen. There ne twenty-five presacral vertebræ, and the neuro-central suture istent. Remains referred to *Champsosaurus* have been found ly in the Lower Eocene of North America, but also in the onding horizon of Belgium and Rheims; the latter specimens been described under the name of *Simædosaurus*. One of ecimens from Rheims indicates an animal of about nine feet th, but other examples appear to have been of considerably palatines;[1] and the premaxillæ never united. The dentition usually acrodont. The ribs may have uncinate processes, and dominal ribs are always developed. The vertebræ may be ei opisthocœlous or amphicœlous, and intercentra may be retained.

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SUBORDER 2. SPHENODONTINA.—This group is characterise the short and more or less triangular skull, in which the premax are produced into a distinct beak; by the longitudinal serie palatine teeth, separated by a groove (into which the hinder ma bular teeth are received) from those of the maxilla (fig. 1037); by the presence of uncinate processes to the ribs.

FAMILY RHYNCHOSAURIDÆ.—This is the most specialised fa and as being most nearly related to *Champsosaurus*, may be noti first. The nares are single; there are no teeth either in the b or in the opposing part of the mandible, which were probably ca in horn; there may be more than a single row of palatine tee and the presacral vertebræ may be more or less opisthocœlo

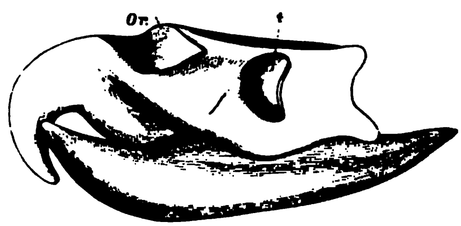


Fig. 1036.—Left lateral view of the skull of *Hyperodapedon Gordoni*, as restored by Professor Huxley; from the Trias of Elgin. Reduced. *Or*, Orbit; *t*, Infratemporal fossa.

The most specialised genus *Hyperodapedon* was originally made known to us by some very imperfect specimens from the Keuper or Upper Trias of Elgin and Warwickshire; but the subsequent discovery of a nearly entire skeleton in the former locality has enabled Professor Huxley to illustrate its full affinities. Remains referred to the same genus also occur in the Maleri stage of the Gondwana system of Central India. The European species attained a length of from six to seven feet, but the Indian form must have been nearly or quite double these dimensions. The skull (fig. 1036) is remarkable for its depressed and triangular form, in which it resembles that of the Chelonian family *Chelydridæ;* and also for the upward direction of the small orbits; the reduced size of the infratemporal fossæ; the strongly-curved and thick premaxillary beak; the diverging clawlike processes of the mandibular symphysis; and the absence of a parietal foramen. Professor Huxley considered that the forked extremities of the mandibular symphysis embraced the premaxillary beak, as is shown in the figure; but later observations indicate that they were received in a pit beneath the beak, which Professor Huxley regarded as containing the apertures of the posterior [he latter probably really formed very small slits on the sides late, as in *Champsosaurus*, and opened between the rows of and palatine teeth. By far the most remarkable feature rer, to be found in the upper den- On the palatal surface of the pecu- gular compound bone (fig. 1037), nay be conveniently termed the axilla, although anteriorly it prob- ludes the vomer, and posteriorly the pterygoid, there are, on the maxillary side, several rows of amidal teeth; then comes the or the reception of the edge of dible, on the inner side of which two or more rows of similar teeth the palatine and vomer, and prob- by the pterygoid. And it is in- to notice that while in the type he larger number of rows of teeth n the palatine and vomer, the re- ndition obtains in the Indian form 37). In the type species there to be no foramen to the humerus, presacral vertebræ are slightly œlous; it is, however, not improb- the vertebræ of the Indian form phicœlous. The extremely solid structure of the palato- causes this part to be the most frequently preserved; and nes are very common in the Indian Gondwanas.

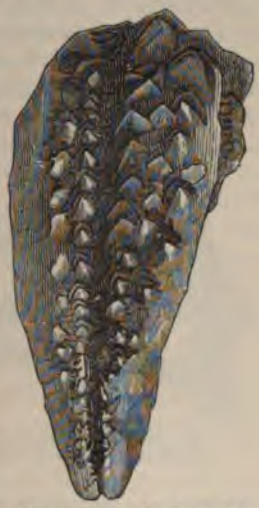


Fig. 1037.—Oral surface of the right palato-maxilla of *Hyperodapedon Huxleyi*; from the Maleri stage of Central India. (After Medlicott and Blanford.)

sor Huxley observes that it is very interesting to note that this had attained its greatest degree of specialisation as early as the *Hyperodapedon* being in all a more modified form than *on*. It appears therefore to be that in the Permian, or per- l earlier, there must have ex- zards differing less from the genus than either *Hyperoda- Rhynchosaurus.*

Fig. 1038.—Right lateral aspect of the skull of *Rhynchosaurus articeps*; from the Trias of Warwickshire. Reduced. (After Owen.)

e typical genus *Rhynchosau-* m the English Keuper, of he type skull is represented 038, there is but a single row of palatine teeth; the orbit and lateral; the infratemporal fossa of considerable size; premaxillary beak long and slender, its form being not correctly shown in the figure of the type skull. The sing scribed species indicates an animal about three feet in l This genus serves in some respects to connect *Hyperodapedo* *Sphenodon.*

FAMILY SPHENODONTIDÆ.—The least specialised family o suborder is solely known by the existing New Zealand *Sphenodon* (*Hatteria*), of which the cranium is shown in fig. According to Professor Huxley's definition, this genus is char ised by the divided nares; the presence of a single tooth on side of the prema beak, which was sheathed in horn the single row o atine teeth; an amphicœlous ver In the palate the goids unite ant with the vome exclude the pal from the mediar Additional disti features are found in the presence of intercentra between vertebræ; in the large size and the lateral position of the the well-developed parietal foramen; and the large size of the and infratemporal fossæ (fig. 1039). The humerus is rema as having both an entepicondylar and an ectepicondylar foran

Fig. 1039.—Right lateral view of the cranium of *Sphenodon punctatus*, of New Zealand. (After Günther.)

The Tuataras, as these lizards are called by the Maories, are m sized reptiles of extreme rarity, and with nocturnal habits. The a border of the dentary bone of the mandible is received in the between the palatine and maxillary teeth, and in old individuals be as hard and polished as the teeth themselves, of which it eventua charges the functions.

SUBORDER 3. HOMÆOSAURIA. — This group includes genera of Mesozoic Reptiles, in which the premaxillæ di apparently form a beak, and the ribs were devoid of ur processes. The dentition is acrodont; but the nature palatal dentition is unknown. The vertebræ are amphic and Dr Baur considers that intercentra were present.

FAMILY HOMÆOSAURIDÆ.—The type family is definitely from the Kimeridgian Lithographic slates of the Continent, characterised as follows. The body is shaped like that of or Lizards; the skull is comparatively broad and short, with oval and a complete postorbital bar; there are no tusk-like teeth premaxillæ or mandible; and the pes is of normal structure.

eridgian genera are *Homœosaurus*, *Ardeosaurus*, and *Sapheo-us*; all of which are represented by species of small or medium . The imperfectly known *Aphelosaurus*, from the Permian of nce, was regarded by the late Professor Gervais as allied, but it indicate a distinct family, which does not belong to this group; number of phalangeals is the same as in existing Lizards.

AMILY PLEUROSAURIDÆ.—This family is typically represented *Pleurosaurus*, of the Kimeridgian of Bavaria, which is a medium-d Lizard characterised by the extreme elongation of the body which there are a great number of presacral vertebræ), and the g narrow skull, with slit-like nares. *Anguisaurus* and *Acro-rus*, of the same deposits, belong to this family; but it does appear certain that they are really distinct from the type us.

AMILY TELERPETIDÆ.—The small *Telerpeton*, of the Upper as of Elgin, differs from the *Homœosauridæ* by the presence usk-like teeth at the extremities of both jaws, and the reduction he number of the phalangeals of the fifth digit of the pes to ; in addition to which Professor Huxley considers that the skull no postorbital bar. The one species is of small size; and ough the genus agrees with the *Homœosauridæ* in its acrodont tition, its serial position must be regarded as provisional. *rosternum*, from the Karoo system of South Africa, is not im-bably an allied genus; although it has been referred by Sir R. en to the Amphibian Labyrinthodonts under the name of *rachosaurus*.

inally, it should be mentioned that Professor Cope includes in present order the genera *Typothorax* and *Aëtosaurus*, which are provisionally placed, on the authority of Dr Baur, among the codilia.

RDER VII. SQUAMATA.—With this order we come to the con-ration of the one represented most numerously at the present , and containing the true Lizards, the Chamæleons, the extinct sasaurians, and the Serpents. In this order the body may be er short, with well-developed limbs and distinct tail (lacerti-n); or it may be extremely elongated, without any external trace limbs, and passing gradually into the tail. As a rule, the whole ly and limbs are covered with overlapping horny scales; and se may be underlain by an armour of bony dermal scutes. The bs may be adapted either for walking on land, or modified into dles for swimming. In the skull the proximal end of the quad- is more or less movably articulated; the lower temporal arcade anting; the postorbital is generally fused with the postfrontal; palate is more or less open, the pterygoids being nearly always arated by an interval from one another; and the premaxillæ are frequently united. The vertebræ are generally procœlous, a rarely amphicœlous; their neurocentral suture is always oblit zygosphenal articulations may or may not be present; an centra are always wanting. The dorsal ribs never have u processes; and true abdominal r likewise never developed. The has but a single centrale; and tl coracoidal process (fig. 1040) is oft marked.

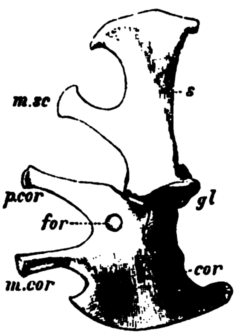


Fig. 1040. — Part of the left pectoral girdle of *Iguana*. *s*, Scapula; *m.sc*, Mesoscapula; *cor*, Coracoid; *p.cor*, Precoracoid; *m.cor*, Mesocoracoid; *for*, Foramen; *gl*, Glenoid cavity.

Three of the groups here rega suborders of the Squamata are fre ranked as distinct orders, but their relations are so close that it app harmonise better with the classi adopted in other branches of the c include the whole of them in a order. The Squamata may be r as occupying a position among I somewhat similar to that held Teleostei among Fishes, and the I among Birds. That is to say, t essentially typical Reptiles, whic attained to a considerable degree of specialisation; and wh have lost, on the one hand, all signs of kinship with the Amp they exhibit, on the other, no traces of especial relationship v Birds. That this order has originated from the Rhyncho there seems but little doubt; but we are very much in the to when or how the divergence took place.

SUBORDER 1. LACERTILIA.—In the true Lizards the fo are usually well developed (fig. 1041) but in some cases one pairs are wanting. The ali- and orbitosphenoidal regions skull are imperfectly ossified; the superior temporal ar generally present; the quadrate articulates with the pte the nasals form a part of the narial aperture; and the ram mandible unite by suture. The vertebræ are in some i amphicœlous; they usually have no zygosphenes, and the in the cervical region does not exceed nine. When li present the pectoral girdle is complete; and the terminal geals of the feet are clawed. Dermal scutes are sometimes and these may be developed on the upper surface of the as to roof over the supratemporal fossæ. Existing Liz divided into twenty families, but only those will be notice occur in the fossil state.

We may commence our notice with a few Mesozoic f which the family position is not yet determined. The form appears to be *Macellodus* (with which *Saurillus* is dentical or very closely allied), from the English Purbeck; Lizard with pleurodont dentition, dermal scutes, and provertebræ. *Adriosaurus* is a larger form from the Lower Green- Austria, also having dermal scutes and procœlous vertebræ, which the dentition is unknown. An allied Continental ic form has received the name of *Hydrosaurus*, which is, r, a synonym of *Varanus*. In the Cambridge Greensand erfect femur and a vertebra indicate a Lizard of the size of f the existing Monitors, but of which the affinity cannot even

Fig. 1041.—The common Skink (*Scincus officinalis*). Reduced.

jectured. In the English Chalk occur the imperfectly known *Coniasaurus* and *Raphiosaurus*; the former having expanded, e latter acute teeth.

e also may be mentioned several genera from the Tertiaries rth America, of which the family position cannot yet be de- ed. The Eocene forms have been named *Tinosaurus* and *aurus*, and those from the Miocene *Aciprion*, *Platyrhachis*, *remastosaurus*. *Notosaurus*, from the Tertiary of Brazil, has cœlous vertebræ, and may be a Rhynchocephalian.

ILY AGAMIDÆ.—The Agamoid Lizards constitute a large , mainly characteristic of Asia, but also occurring in Europe, , Australia, and Polynesia. The supratemporal fossa is not over; the dentition is acrodont; and the premaxillæ are te. Specimens referred to the type genus *Agama* have been ed from the Upper Eocene Phosphorites of Central France; the Pleistocene of Australia has yielded a skull indistinguish-

able from that of the existing Frilled Lizard (*Chlamydosauru*
of the same country.

FAMILY IGUANIDÆ.—The Iguanoids are readily distinguisl the *Agamidæ* l pleurodont d (fig. 1042), a presence of zyg al articulations vertebræ (fig. Nearly all the are now confi

Fig. 1042.—Inner view of left ramus of the mandible of *Iguana*.

the New World. In the Upper Eocene (Oligocene) Phosphc Central France there occur, however, fragments of jaws whi been referred to the typical Aı genus *Iguana;* that term bein in a wider sense than in recent ology. Vertebræ also occur approximately equivalent depc Hordwell in Hampshire (of wh is represented in fig. 1043), whic in the presence of small zygo with those of existing Iguan have been provisionally referred to the French species. Th *Iguanavus* has been applied to remains of a member of thi from the Eocene of North America.

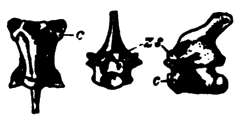


Fig. 1043. — Vertebra of *Iguana europæa*, viewed from the hæmal, anterior, and lateral aspects; from the Upper Eocene of Hampshire. *zs*, Zygosphene; *c*, Costal tubercle.

FAMILY ANGUIDÆ.—The *Anguidæ* are characterised by tl ence of scutes roofing over the supratemporal fossæ; by the tion of the premaxillæ and the nasals; the more or less con pleurodont dentition; and the presence of dermal scutes with minute tubercles. The genus *Ophisaurus* (*Pseudopus*), i the limbs are either wanting or are reduced to rudiments of th pair, is represented in the Middle Miocene of Gers, in Fran the Lower Miocene of Rott, near Bonn; some of the species been originally described under the name of *Anguis*. *Propse* from the Middle Miocene of Steinheim, in Bavaria, is distin from *Ophisaurus* by its stronger dentition and the presen double row of teeth on the vomer. The genus *Peltosaurus* allied *Exostinus*, of the Miocene of North America, may be i in this family; to which we may also refer several Europ American Upper Eocene genera which have been regarded stituting a distinct family under the names of *Placosauri Glyptosauridæ*. Among these *Placosaurus* (*Palæovaranus* the Upper Eocene of France and England, has teeth res those of the Slow-worm (*Anguis*), which were originally rega belonging to a Varanoid; the vertebræ (fig. 1044) are not

e of the existing *Diploglossus*, and the limbs were well de-
oped. Another Anguoid, with blunt cylindrical teeth, from the
ercy Phosphorites, was originally referred to the Scincoid genus
meces (*Plestiodon*), but its generic position must for the present
ain undecided. In North
erica we have *Glyptosau-*
, from the Bridger Eocene
Wyoming, in which the
tebræ have rudimental
osphenes; the large *Sa-*
a, of which the dermal
tes are unknown; and
apparently allied *Xestops*
rosaurus). The vertebræ

Fig. 1044.—Vertebra of *Placosaurus margariticeps*, viewed from the hæmal, anterior, and lateral aspects; from the Upper Eocene Phosphorites of Central France. *c*, Costal tubercle.

these genera, like those of existing *Anguidæ*, present a strong
emblance to those of the next family, as may be seen by com-
ring fig. 1044 with fig. 1045.

FAMILY VARANIDÆ.—The Monitors include the largest known
ards; one of the fossil species attaining a gigantic size. They
confined to the Old World and Australia; and appear to be
known before the Pliocene. The skull has no postorbital bar;
e supratemporal fossæ are not roofed over by bony scutes; and
th the premaxillæ and the nasals are united. The dentition is
eurodont; and the teeth are large and pointed, and confined to
e jaws. The vertebræ are characterised by their broad and flat
ntra (fig. 1045); and dermal scutes are wanting. All the known
rms may be included in the single genus *Varanus*.

In existing forms the dorsal vertebræ are elongated, and have broad
ural spines; and the largest species attains a length of seven feet. In
fossil state this group is represented
remains from the Pleistocene of Ma-
as apparently referable to the living
bengalensis. Other vertebræ, again,
und in the corresponding cave-de-
sits of Queensland, not improbably
long to one or more of the species
ill inhabiting that region. In a
cond and extinct group the dorsal
rtebræ are relatively shorter and
der, and have narrower neural spines;
e two known species being of very
rge size. The smaller of the two is
sivalensis, from the Pliocene of the
iwalik Hills of India, of which a dor-

Fig. 1045.—Hæmal aspect of a dorsal vertebra of *Varanus sivalensis*; from the Pliocene of the Siwalik Hills.

al vertebra is shown in fig. 1045. Another vertebra is, however, larger
han the figured specimen; and the total length of the animal was prob-
bly at least twelve feet. These dimensions were, however, greatly ex-
eeded by the huge *V. priscus*, of the Pleistocene of Australia, in which

the vertebræ are three times the size of those of *V. sivalensis*, total length did not probably fall short of thirty feet. This speci originally described by Sir R. Owen under the name of *Megalania*; tain remains which were referred to it having subsequently pro be Chelonian. An imperfectly known species, from the Lower Pli of Attica, may perhaps belong to the former group.

It may be well to mention here that Sir R. Owen has desc two peculiar blunt and pleurodont teeth of a large lizard fro Pleistocene of Queensland under the name of *Notiosaurus*, w is, however, preoccupied by the genus *Notosaurus* (p. 1139). just possible that these teeth may be referable to *Varanus pri* in which event the generic term *Megalania* would have to be tained for that form.

FAMILY TEIIDÆ.—In this family, which is confined to Ame the supratemporal fossæ of the skull are not roofed over, the d tion is pleurodont or subacrodont; the teeth, although variabl form, are always solid at the base; and there are no dermal sc An existing species of *Tupinambis* is represented in the Pleisto cave-deposits of Brazil.

FAMILY LACERTIDÆ.—In the *Lacertidæ* the supratemporal fo are roofed over by bone; the premaxillæ are united; the denti is pleurodont, the bases of the teeth being hollow; and there are dermal scutes. All the genera belong to the Old World. Rem of the existing *Lacerta ocellata* occur in the Pleistocene of Fran and extinct species referred to the same genus have been describ from the Miocene and the Upper Eocene Phosphorites of the sa country.

FAMILY SCINCIDÆ.—The Scincoid Lizards form a large cosmo-politan family, characterised by the bony scutes roofing over the supratemporal fossæ; the separate or imperfectly united premaxillæ; the pleurodont dentition; and the presence of dermal scutes. *Dracænosaurus*, of the Lower Miocene of France, is an extinct genus with molariform teeth, probably allied to the existing *Scincus* (fig. 1041) or *Chalcides*.

SUBORDER 2. RHIPTOGLOSSA.—The *Chameleontidæ*, or Chameleons, differ from the Lacertilia in that the nasals do not enter into the borders of the nares; the pterygoid does not articulate with the quadrate; and, although limbs are present, there are no clavicles or interclavicle. The dentition is acrodont. All the existing forms are Old World; but Dr Leidy has described part of a mandible from the Upper (Bridger) Eocene of Wyoming, which he refers to the type genus *Chameleon*.

SUBORDER 3. DOLICHOSAURIA.—This group was originally formed for the reception of the genus *Dolichosaurus*, from the English Chalk; which is a small snake-like Lizard, with more than nin tebræ in the neck, and well-developed limbs. The vertebræ re zygosphenal articulations. *Acteosaurus*, from the Cretaceous Austria, is an allied form.

SUBORDER 4. PYTHONOMORPHA.—The Mosasauroids are car-vorous marine Reptiles, frequently of large dimensions, and nging in time from the Upper Greensand to the topmost Creta-ceous, with a cosmopolitan distribution. The body is much elon-ted. The skull (fig. 1047) presents a strong resemblance to that the *Varanidæ* among the Lacertilia, and has the nasals and pre-axillæ welded together, the quadrates ry loosely articulated, teeth on the erygoids as well as in the jaws, and equently ossifications in the sclerotic the eye. The teeth are large and arp, and anchylosed by expanded ses to the summits of the jaws. here may be zygosphenal articulations the vertebræ, and the cervical region ay include more than nine vertebræ. he clavicles are always, and the inter-avicle and sacrum generally, wanting; ut Professor Marsh figures a sternum one genus. The limbs are modified to paddles (fig. 1046), with no claws to he terminal phalangeals, and no fora-men to the humerus. The development f the pelvis is, moreover, but imperfect, nd at least the majority of forms appear o have been devoid of dermal scutes, lthough Professor Marsh has recorded heir presence in one genus.

Fig. 1046.—Right pectoral limb of *Platycarpus*; from the Cretaceous of North America. One-twelfth natural size. *a*, Scapula; *b*, Coracoid; *c*, Humerus; *d*, Radius; *e*, Ulna. (After Marsh.)

FAMILY PLIOPLATYCARPIDÆ. — The east specialised form seems to be the enus *Plioplatycarpus*, of the Upper Cre-aceous of Holland, in which both an interclavicle and a sacrum re present; on which account its describer, M. Dollo, regards it s the type of a distinct family.

FAMILY MOSASAURIDÆ.—The whole of the remaining genera of the suborder may be included in this family. One of the well-known genera is *Clidastes* (from which *Edestosaurus* is regarded by Professor Cope as inseparable), from the Cretaceous of North America. This genus comprises numerous species, characterised by the extreme elongation of the body, and their small or medium size. In the skull the teeth, as in the next genus (fig. 1047) are continued to the extremity of the premaxillæ; the vertebræ are long, and have zygosphenal articulations; the humerus is short; and the chevrons are anchylosed to the centra. *Sironectes* is an allied genus from the same deposits, in which the chevrons are not anchylosed to the vertebræ. *Platycarpus*[1] (*Lestosaurus*, *Taniwhasaurus*), which is found in the Cretaceous of North America, New Zealand, and perhaps Europe, differs from both the preceding

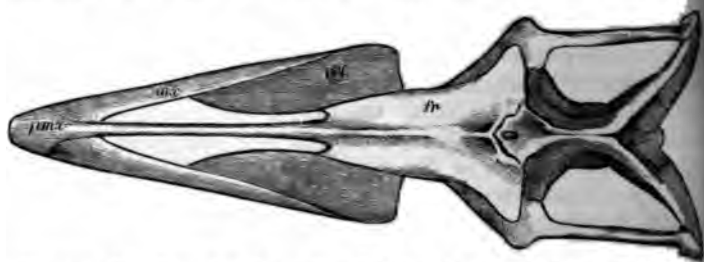


Fig. 1047.—Frontal aspect of the cranium of *Platycarpus curtirostris*; from the Upper Cretaceous of North America. Greatly reduced. *pmx*, Premaxilla; *mx*, Maxilla; *fr*, Frontal; *prf*, Prefrontal. (After Cope.)

genera by the absence of zygosphenes; the chevrons being free and the humerus (fig. 1046) short and broad. With the genus *Liodon*, in which Professor Cope includes *Tylosaurus* (*Rhinosaurus*) of Professor Marsh, we come upon forms attaining gigantic dimensions, in which the body is proportionately shorter than in the above-mentioned genera, and the vertebræ are always without zygosphenes. In *Liodon* itself the extremity of the premaxillæ is devoid of teeth, and forms a cylindrical rostrum; the teeth are smooth and more or less laterally compressed; the humerus is long; and the chevrons are free. It occurs in the Cretaceous of Europe, North America, and New Zealand. *Hainosaurus*, again, of the Upper Chalk of Mons, agrees with *Liodon* in its edentulous rostrum and free chevrons, but has teeth of three types. Some of the teeth are subcylindrical, and others compressed, with serrated cutting edges like those of *Megalosaurus*. The total length of this huge Reptile is estimated at about 40 feet. The typical genus *Mosasaurus* is definitely known from the topmost Cretaceous of Maastricht in Holland, and the Cretaceous of North America; the type species from Maastricht having been made known to science in the last century. It is characterised by the premaxillæ being toothed to their extremity; by the teeth having their crowns faceted and more or less compressed; as well as by the greater number of the chevrons being anchylosed to the vertebræ. The fine skull of *M. Camperi* represented in the accompanying woodcut was obtained from Maastricht previously to 1785, and is preserved

[1] Amended from *Platecarpus*.

the Paris Museum. This species is estimated to have attained a length of 25 feet. Closely allied to *Mosasaurus* is *Pterycollasaurus*, which is, however, readily distinguished by the complete union of the pterygoids in the middle line—a feature unknown elsewhere

Fig. 1048.—The imperfect skull of *Mosasaurus Camperi;* from the Upper Cretaceous of Maestricht. Much reduced. The displaced bone in the left bottom corner is the left pterygoid, the corresponding bone of the opposite side being in its natural position above.

in the whole order. The only known species is *P. Maximiliani*, of the Cretaceous of Brazil. Finally, the genus *Baptosaurus*, of the Cretaceous of North America, is distinguished from all other genera by the complete union of the hæmal spines of the cervical vertebræ

Fig. 1049.—Left lateral and upper view of the skull of *Boa*. *pmx*, Premaxilla; *na*, Nasal; *pr*, Prefrontal; *fr*, Frontal; *po*, Postfrontal; *pa*, Parietal; *pc*, Proötic; *sq*, Squamosal; *qu*, Quadrate; *pt*, Pterygoid; *tr*, Transverse; *mx*, Maxilla; *ar*, Articular; *de*, Dentary.

with the centra. The Mosasaurs attained their maximum development at a time when the Ichthyosaurs were on their decline.

The very imperfectly known *Cetarthrosaurus*, of the Cambri Greensand, which Mr Hulke refers to this order, is noticed am the Ichthyopterygia.

SUBORDER 5. OPHIDIA.—The Serpents and Snakes constituting last division of the Squamata present the following distinctive tures: The body is greatly elongated (fig. 1051, *bis*), and the verte column divisible only into a trunk and a caudal region. The phenoidal region of the skull is fully ossified; there is no temp arcade, parietal foramen, or columella; the quadrate and the bo of the palatal and maxillary regions are loosely attached to the (fig. 1049); the premaxillæ are more or less aborted and usu edentulous; and the two rami of the mandible are connected by ligament. The vertebræ (fig. 1050) have zygosphenes; but th is no sacrum, and chevrons are also wanting. There is, moreov no sternum, nor any trace of the pectoral girdle or limbs; but some cases there are rudime of the pelvic girdle and lim Dermal scutes are invari wanting. This suborder is vided into three sections; b since its palæontological hist is but imperfectly known, o very brief mention will be ma of those families represented a fossil state. With the excep-

A B

Fig. 1050.—Posterior (A) and hæmal (B) views of a trunk vertebra of *Python molurus*; from the Pleistocene of India.

tion of an imperfectly known form from the Chalk, described under the name of *Cimoliophis*, all the known fossil forms are of Tertiary or Post-tertiary age. The next earliest genus is *Helagrus*, of the Lowest (Puerco) Eocene of North America, in which the imperfect development of the zygantrum of the vertebræ indicates very generalised affinities.

FAMILY COLUBRIDÆ.—The first existing family of the section Colubriformes, or Innocuous Snakes, contains the great bulk of the suborder; and, with the exception of Australia, is represented in nearly all temperate and warm regions. The Indian genus *Ptyas* is probably represented in the Pleistocene of Madras by the existing *P. mucosus*. In the Middle Miocene of France we have the extinct *Pilemophis* closely related to the modern *Tropidonotus*, or common English Snake; while the existing genus *Elaphis* occurs in the Upper and Lower Miocene of various parts of the Continent. A species of *Periops* closely allied to one now living in Egypt occurs in the Pleistocene of Coudes, in the south of France; and *Thamnophis*, from the Middle Miocene of the latter country, is said to be allied to *Elaphis*.

FAMILY PYTHONIDÆ.—The Pythons, or Rock Snakes, are now ned to Africa, Asia, or Australia; and, with the next family, ide the largest existing representatives of the suborder. They teeth in the premaxilla; and all of them are good swimmers. ains of the existing Indian *Python molurus* (fig. 1050) are d in the Pleistocene of Madras; and not improbably also in Pliocene of the Punjab; while in the Pleistocene of Australia r vertebræ probably referable either to *Narboa* or *Liasis*, which inhabit that continent. From the Upper Eocene (Lower Oligo-) freshwater deposits of Hampshire, and the equivalent Phos-rites of Central France, we have the genus *Paleryx* (*Palæo-on*), which is apparently nearly related to *Python*. Finally, *alophis*, from the Quercy Phosphorites, is said to connect the *honidæ* with the *Tortricidæ*.

AMILY BOIDÆ.—The Boas are at the present day confined to New World, and differ from the *Pythonidæ* by the absence of naxillary teeth (fig. 1049). The genera *Boavus*, *Lithophis*, and *ophis* (*Limnophis*), of the Upper Eocene of North America, are ably referable to this family. *Protagrus*, from the same de-ts, may also be provisionally included in this family; to which s been suggested that *Botrophis*, of the French Miocene, may wise belong.

AMILY ERYCIDÆ.—The members of this family are small Snakes d to the *Boidæ*, but having a much shorter and non-prehensile *Scaptophis*, of the Middle Miocene of France, is regarded as d to the existing African *Eryx*; while in the Miocene of North erica we have *Aphelophis*, *Calamagrus*, and *Ogmophis*, all of ch appear to be more or less closely related to the genus *rina* now inhabiting the same regions.

AMILY PALÆOPHIDÆ.—Here we may provisionally place the ily formed for the reception of the extinct genus *Palæophis*,

Fig. 1051.—Vertebra of *Palæophis typhæus*; from the Middle Eocene of England. The neural spine is wanting. *c*, Costal tubercle; *zs*, Zygosphene.

m the Lower and Middle Eocene of Europe, comprising very ge Serpents, which were probably of marine habits. The vertebræ (fig. 1051) differ from those of the *Pythonidæ* (fig. 105 their much taller neural spines, the lower position of the c articular surfaces, the less divergence of the zygapophyses, an the stronger development of the hæmal ridge on the inferior s of the centrum, which often carries well-marked processes a two extremities. The type genus *Palæophis* is represented by English species, of which the largest is estimated to have att a length of 20 feet. In the Eocene of North America we closely allied forms reaching to a length of 30 feet, which a ferred by Professor Marsh to a distinct genus under the nan *Titanophis* (*Dinophis*), but which Professor Cope regards as i tinguishable from *Palæophis*. By Sir R. Owen these snake regarded as allied to the existing marine Sea-snakes or *Hydrop*

FAMILY ELAPIDÆ. — The first existing family of the se Colubriformes Venenosi includes the Cobras (*Naia*, fig. 1051 and Coral-snakes (*Elaps*). The former genus probably occu the Pleistocene of Madras; and perhaps also in the Middle Mi of Steinheim, in Bavaria.

FAMILY VIPERIDÆ.—The present and following families c tute the section Viperiformes; characterised, among other fea by the perfect development of the poison-apparatus. A snake the Upper Miocene of Switzerland has been referred by M. R brune to the existing genus *Bitis* (*Echidna*); having been orig described under the name of *Coluber Kargi*.

FAMILY CROTALIDÆ.—The Pit-Vipers and Rattlesnakes are fined at the present day to Asia and America. The genus *A dromicius*, from the Miocene of North America, is provisic referred by Professor Cope to this family; while *Laophis*, the Tertiary of Salonica, has also been regarded as a memb the same group.

ORDINAL POSITION UNCERTAIN.—It will be convenient to tion here two imperfectly known genera from the English Purl of which the ordinal position cannot at present be determ They were regarded by Sir R. Owen as belonging to the Lace but their teeth are much more of a Dinosaurian type. The genus, *Nythetes* (*Nuthetes*), is represented by a species of the si some of the existing *Varanidæ*, but has teeth closely resembling of the *Megalosauridæ*, although it is said that they were not impl in distinct sockets, and were anchylosed to the bone. The se genus, *Echinodon*, is a smaller form, in which the teeth pres striking resemblance to the much larger ones of the Dinosa genus *Scelidosaurus*; they were implanted in imperfect sock

Here also may be mentioned the remarkable genus *Atoposa* from the Kimeridgian lithographic limestones of Bavaria, includes two species of small Lizard-like Reptiles, presentin wing peculiar features. The manus seems to be of a Rhyn-cephalian type; but the pes has only four digits, in which the langeals number 2, 3, 4, 4, or the same as in the Crocodilia. proximal bones of the carpus are also elongated, as in that er; and the radius and ulna in the pectoral, and the tibia and la in the pelvic limb, are respectively in close apposition. The dibular symphysis is long; and the dentition is said to resemble of the *Geckonidæ* among the Lacertilia. The above characters t to a curious blending of Squamatine and Crocodilian features.

Fig. 1051, *bis*.—The African Cobra (*Naia haje*). Reduced.

CHAPTER LV.

CLASS REPTILIA—continued.

ORDERS DINOSAURIA, CROCODILIA, AND ORNITHOSAURI

ARCHOSAURIAN BRANCH. — The three orders constituting branch comprise the most highly developed of all Reptiles those which make the nearest approach in their organisati the Avian type. They also include the largest forms yet k not only among Reptiles, but also among all Vertebrates ad for a life on land. The following features are common t entire branch. The teeth are very generally implanted in di sockets; are never anchylosed to the bones of the jaws; ar exclusively confined to the premaxilla, maxilla, and dentary l Both the pectoral and pelvic limbs are always well developed cranium has no parietal foramen, but is furnished with b superior and an inferior temporal arcade (as is shown in the of the Crocodilian skull on p. 1181); the quadrate is firmly among the adjacent bones; and there is frequently no colu The anterior ribs have a distinct capitulum and tuberculum dorsal vertebræ carry long transverse processes, which m placed entirely on the arch; and there may be more than tw tebræ in the sacrum. There is never a T-shaped interclavicl the only indication of the precoracoid is afforded by the font in the coracoid, which indicates its original duality. The hu has no foramen, but an ectepicondylar groove may occur. proximal row of the tarsus comprises two bones, representir astragalus and calcaneum. Abdominal ribs are generally pr The number of phalangeals in the limbs approximates more c closely to that obtaining in the Streptostylic branch, althou some cases there is a reduction. The lateral surface of the n bular ramus may have a vacuity. As a rule the centrum c atlas vertebra forms an odontoid process more or less clos tached to the centrum of the axis; the arch of the former ported by the crescent-shaped first intercentrum. Generally the ond intercentrum, like that of Birds, was likewise fused with centrum of the axis; but in one Dinosaur (? *Megalosaurus*) element exists as a distinct wedge-like bone.

In the pelvis the pubis and ischium never form the broad and tened plates found in the Synaptosaurian branch, and they frently assume a more or less rod-like form with expanded exmities (fig. 1073). The ilium (*ibid.*) frequently presents an anded form; and the obturator notch is never converted into oramen.

ORDER VIII. DINOSAURIA.—The Dinosaurs comprise the largest nd Reptiles; and while some of them approximate closely to the pe of structure obtaining in Birds, others come so near to the ore generalised Crocodilians that it is almost impossible to give y definition of the order that will separate it from the latter. It indeed, probable that in the Lower Trias there lived the common cestors of the two orders, and the forms from the upper division the same period indicate not only the close connection between ese two groups, but also show some signs of affinity with the hynchocephalia.

It has recently been proposed to divide the Dinosauria into two ders, from the structure of the pelvis, for which the names Orithischia and Saurischia have been proposed. If, however, this iew be eventually accepted, it would be advisable to adopt the ame Ornithopoda for the first division, and to restrict the term inosauria to the second, which would include the two groups here rmed Theropoda and Sauropoda. In regard to the names of the borders, it should be mentioned that Professor Cope first proposed e names Orthopoda and Goniopoda for the groups here termed rnithopoda and Theropoda, on the ground that the relations of e tibia and fibula were essentially different in the two. According, owever, to Professor Huxley, this alleged difference does not exist, nd these names are therefore rejected by him.

This order is entirely extinct, and may be regarded as charactertic of the Mesozoic period; since it ranges from the Trias to the ppermost Cretaceous of Maastricht, and the Laramie beds of the nited States, and appears to have attained its maximum developent in the Jurassic and Wealden. In space this order was widely istributed over Europe and North America; and it has also been et with in India and Africa.

Dinosaurs vary exceedingly in the contour of the body and limbs; hich in some instances were more or less of a crocodilian type, but n others approach very markedly to the avian structure; the latter eature being most marked in the pelvis and hind limbs. The hind imbs were either moderately or excessively long; while the body was sometimes defended by a bony dermal armour, which carry long spines, but apparently was never composed of imbric pitted scutes. The centra of the vertebræ are very generally cœlous; but are not unfrequently opisthocœlous in the cervica more rarely in the anterior dorsal region; and occasionally the caudals are procœlous. The neuro-central suture was persistent till an advanced period of life. As a general rule sacrum includes from three to six vertebræ, but occasionally number is reduced to two. The cervical ribs are not produced spines directed antero-posteriorly; and there are no uncinate cesses to the ribs. The rib-facets of the middle dorsal verte may either form a "step" on the transverse process, as in the C codilia, or may be placed on the lamina of the arch. The skull many features of that of the earlier Crocodilia, but also seems approximate in some cases to the Rhynchocephalian type. The maxillæ were but rarely fused together; and the union of the dibular rami in the symphysis is cartilaginous. The teeth are erally more or less laterally compressed, frequently having serra edges, and may be of complex structure; they were not alwa implanted in distinct sockets. The sternal region is imperfec known, but it frequently comprised two paired bones, which represent parts of the sternum. The limb bones may be eith solid or furnished with a medullary cavity. The coracoid has fontanelle, and is always short and rounded. In the pelvis (fig 1060) the ilium has both the pubic and preacetabular process well developed, the latter being in some cases greatly elongated; the pubis always takes a share in the formation of the acetabulu (of which the inner wall is unossified), and may be directed eith forwards or backwards. The femur may have its head placed either obliquely (as in the Crocodilia) or at right angles to the condyles; and may or may not be furnished with an inner trochanter. The tibia, as in Birds, had a cnemial crest; and the astragalus was fre quently flattened, and more or less closely applied to the lower end of the tibia.

SUBORDER I. ORNITHOPODA.—This suborder is taken to include the Stegosauria of Professor Marsh, and embraces the most special ised forms. In the skull (figs. 1059, 1062) the anterior part of the premaxilla is devoid of teeth; there is no preorbital vacuity; the nares are placed at the extremity of the skull; and the teeth are more or less complex, and are frequently not set in distinct sockets The vertebræ are solid throughout. The pectoral limb is consider ably shorter than the pelvic; the limb bones may be either soli or hollow. The ilium generally has its preacetabular process much elongated (fig. 1060), although this is not the case in the type o *Camptosaurus* (fig. 1052), the ischium has an obturator process e most striking and remarkable feature in the group, and one ch it differs from all others except Birds, is that the shaft of bis is directed backwards more or less nearly parallel with the n, while a shorter and thicker portion in advance of the ulum projects forwards. How remarkably this pelvic struc- pproximates to that of Birds may be seen by comparing figs. and 1060 with that of the pelvis of a Ratite Bird given in the Thus the large preacetabular process of the pubis of the ur corresponds with the much smaller but similarly situated

2.—The left side of the pelvis of *Camptosaurus dispar*; from the Upper Jurassic of erica. One-twelfth natural size. The upper bone is the ilium, that on the left the l that on the right the ischium. (After Marsh.)

al process in the pelvis of the Ratite Birds (fig. 1107). In cases the pubis had no median symphysis. All the more ised members of the suborder appear to have walked habitu- the hind limbs alone. In this and the following suborder gth of the tibia is often nearly equal to that of the femur; *Hysilophodon* and *Compso-* s the former bone, as in is the longer of the two.

Fig. 1053.—Tooth of *Trachodon Foulki*; from the Upper Cretaceous of New Jersey. (After Leidy.)

ILY TRACHODONTIDÆ. — ost specialised, as well as the most recent, families of order, seems to be that typ- represented by the genus *don* (*Hadrosaurus*). This family, although closely related next, is distinguished by having the teeth arranged in a r of vertical columns and articulating together so as to form a kind of pavement. The type genus, of which a tooth shown in fig. 1053, was first described from the Upper Cretace of the United States, but has been subsequently recorded from t Upper Greensand of Cambridgeshi All the dorsal vertebræ are opist cœlous. Five other genera—viz., *D clonius*, *Cionodon*, *Monoclonius*, *D canus*, and *Agathaumas*—from Laramie beds of North America p sent a similar type of dentition, a have been referred to the sa family; the first being probably id tical with *Trachodon*. The Laran beds, it should be observed, app to be transitional between the C taceous and Eocene although re able to the former epoch. In the so-called *Diclonius* the sk although presenting many of the features of that of *Iguanod* is much more elongated and depressed, and has the edentul premaxillæ produced in advance of the large nares. *Orthomer*

Fig. 1054.—Four lower teeth of *Iguanodon* in the jaw. Reduced.

Fig. 1055.—Inner (A) and outer (B) aspects of a lower tooth of *Iguanodon bernissartensi* from the Wealden of Sussex.

of the Upper Cretaceous of Maastricht in the Netherlands, r probably be also referred to this family, although it shows so signs of connection with the next.

FAMILY IGUANODONTIDÆ.—The characteristic features of this markable family are to be found in the hollow limb bones;

slenderness and relative length of the pubis and ischium (figs. 1052, 1060); the avian characters of the femur, which has a large inner trochanter; the digitigrade hind-foot, furnished with either three or four digits and more or less elongated metatarsals; and the short pectoral limbs. The bones usually referred to the sternal region are typically hatchet-shaped, and have been regarded by some authorities as clavicles, although it seems more probable that they are connected with the xiphisternum. The cervical vertebræ were usually opisthocœlous; and the rib-facets in the middle dorsal region were placed on the arch. The teeth (figs. 1054, 1055) were arranged in a single row, and are very peculiar and characteristic. Thus they have flattened, diamond-shaped crowns, bearing strongly-marked serrations on the anterior and posterior borders, and one

Fig. 1056.—*Iguanodon bernissartensis*. The skeleton; from the Wealden of Belgium. About $\frac{1}{75}$ natural size. The scale indicates metres. (After Dollo.)

or more vertical ridges, some of which may themselves be serrated, on their outer aspect. The mandible, again, presents the peculiar feature of having a horse-shoe-like predentary bone at the extremity of the symphysis (fig. 1059). This predentary ossification is devoid of teeth; while the mandibular symphysis itself is deeply channelled. The family ranges from the Middle Jurassic to the Wealden and Neocomian of Europe; its members generally showing a gradual increase in size from the lower to the higher horizons. Like the members of the preceding family, the Iguanodonts habitually supported themselves on the hind limbs, as in the accompanying figure.

In the imperfectly known *Sphenospondylus* of the English Weal the anterior dorsal vertebræ were opisthocœlous, and all the do had very low neural arches. In the type genus *Iguanodon*, w includes the largest forms, the skull (fig. 1059) is comparati short, with large and terminal nares and no teeth in the pre illa. In the typical forms, constituting the Euiguanodont gr the dorsal vertebræ (fig. 1058) are amphicœlous, those in anterior part of the series having very tall neural arches compressed centra; while the sacral vertebræ are anchylosed gether, and have rounded inferior, or hæmal, surfaces. In pelvis (fig. 1056) the ilium is shallow, with a sharply pointed p acetabular process; while the pubis is much shorter than

Fig. 1057.—Inner aspect of the left femur of *Iguanodon bernissartensis* (A), and of *Camptosaurus Leedsi* (B). Reduced to same size. *a*, Head; *b*, Lesser trochanter; *c*, Inner do.; *d*, Ectocondyle; *e*, Entocondyle.

Fig. 1058.—Posterior aspect of anteri sal vertebra of *Iguanodon bernissart* from the Wealden of the Isle of Wight. sixth natural size. (After Seeley.)

ischium (which is twisted on itself), and does not form a symph The femur (fig. 1057, A) is characterised by the inner troch (*c*) forming a crest directed almost immediately backwards, w its shaft is nearly straight. The foot had only three functi digits, of which the metatarsals were short and thick, and phalangeals broad and flat; while in the manus the one phalar of the first digit, or pollex, was modified into a stout conical s As in the other members of the family, the astragalus, althougl anchylosed to the tibia, was closely applied to its distal extremity, and thus rendered the structure of the ankle-joint (as in many other members of the order) essentially similar to that of a Bird.

It may be observed that the inner trochanter of the femur corresponds to the small one found in some Birds, which gives attachment to the femoro-caudal and ischio-femoral muscles, and it is interesting to find, from the observations of M. Dollo, that its form in *Iguanodon* is that which agrees with the Avian type.

Iguanodon ranges from the Wealden to the Lower Greensand, and hitherto has only been described from Europe. The two representatives of the typical or Euiguanodont group occur in the Upper Wealden and Lower Greensand, and comprise *I. Mantelli*, and the larger *I. bernissartensis* (fig. 1056); these two species being also distinguished from one another by the number of the sacral vertebræ, and the contour of the ilium and femur.

The length of the entire body of the larger *I. bernissartensis* is estimated at about 33 feet. The history of the gradual reconstruction of the skeleton of this genus affords an instructive instance of the results which may be attained by careful and patient study of fragmentary remains.

Fig. 1055.—Left lateral aspect of the skull of *Iguanodon bernissartensis*; from the Wealden of Belgium. Much reduced. The anterior aperture is the nares; the middle one the orbit; and the posterior the infratemporal fossa. The predentary bone is seen at the extremity of the mandible. (After Dollo.)

By the labours of the late Dr G. Mantell of Lewes, in the first half of this century, a considerable knowledge was acquired of the greater part of the skeleton, although the structure of the pectoral and pelvic girdles remained a puzzle. The structure of the latter was, however, after more than one ineffectual attempt, finally solved by the labours of Professor Huxley and Mr J. W. Hulke.

In the Wadhurst Clay, or Lower Wealden, of Sussex, we meet with three species of *Iguanodon* which connect the preceding typical

forms with the undermentioned genus *Camptosaurus*. *I. Daw*
a form intermediate in size between *I. Mantelli* and *I. bernissart*
characterised by the less compressed centra and lower arches
dorsal vertebra; and also by the form of the ilium (fig. 106
which is of great depth, and has a deep and rounded postacet
process, while the preacetabular process has a horizontal in
plate. In the smaller *I. Fittoni* the ilium is equally deep, b
the postacetabular portion narrowed to a point laterally, with
tinct inferior horizontal plate; while the sacrum has laterally

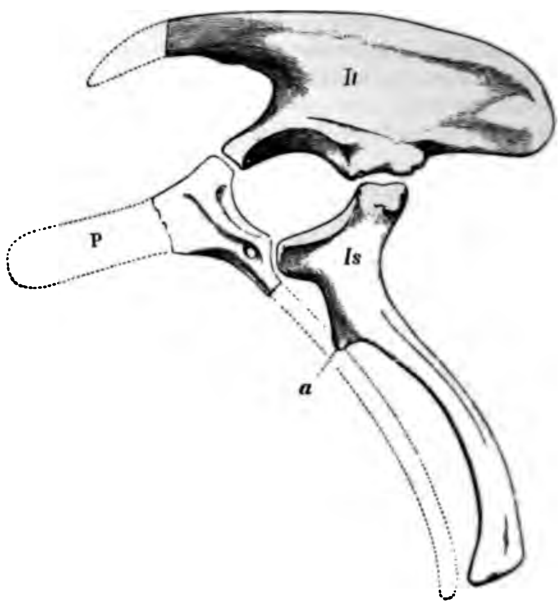


Fig. 1060.—Left pelvic bones of Lower Wealden Iguanodons. One-sixteenth natural s
Ilium of *Iguanodon Dawsoni*; *P*, Imperfect pubis of do.; *Is*, Ischium of *I. hollingt*
a, Obturator process of ischium.

pressed vertebræ like those of *I. Mantelli*. The posterior p
of the ilium of this species is indeed almost indistinguishable
that of *Camptosaurus* (fig. 1052). Finally, in *I. hollington*
which agrees approximately in the proportions of the limbs
I. Mantelli, the femur had a curved shaft and pendant troc
as in *Camptosaurus* (fig. 1057, B); while the sacrum had th
tebræ remaining separate from one another, with their in
surfaces flattened, as in that genus, with which this specie
agreed in the contour of the ischium (fig. 1060, *Is*), which
stout shaft not twisted upon itself. This species agreed, how

e typical species of the genus in having the pollex modified conical spine, and thereby differed from *Camptosaurus*, h indicating how the one genus passed into the other. It improbable that the large Iguanodont from the Upper c of the United States, described as *Camptosaurus amplus*, be referred to this group of *Iguanodon*, since it has but functional digits in the pes.

h the genus *Camptosaurus* (*Camptonotus*), we come to forms are usually of smaller size than the preceding. It occurs lly in the Upper Jurassic of North America; but certain from the English Oxford and Kimeridge Clays, to the latter ich the name *Cumnoria* has been applied, as well as a Wealden s, do not appear to be generically separable. This genus has of somewhat simpler structure than those of *Iguanodon*, and is r characterised by the flattened hæmal surfaces of the centra e sacral vertebræ, which appear to have remained separate hout life; by the short preacetabular process of the ilium 052) of the type species; by the equality in the length of the and ischium; by the pendant, or downwardly directed, inner nter of the curved femur (fig. 1057, B); and the presence of igits of normal structure in the manus, and typically of four pes. The length of the femur of the type species is some ches. The English forms are not fully known; but so far as the case they agree in essential characters with the type: the ure of the manus and pes is, however, unfortunately unknown. *edsi*, of the Oxford Clay, is known only by the femur (fig. B), which measures a little over one foot in length; while in imeridgian *C. Prestwichi* (the type of *Cumnoria*) we are acted with the greater part of the vertebral column, in which the ls have tall neural arches, while the ilium has a long preacer process like that of *Iguanodon*. The Wealden *C. valdensis* ified by a femur. *Laosaurus* is an allied form from the Upper sic of the United States, distinguished by its amphicœlous al vertebræ. The imperfectly known *Cryptodraco* (*Crypto-s*), from the Oxford Clay of England, is characterised by the stoutness of the femur, which exceeds a foot in length, and straight shaft, with an inner trochanter like that of *Iguanodon ssartensis*, but differs from the corresponding bone of all other bers of the family in the absence of a groove on the anterior t of the lower end between the condyles.

stly, we come to the consideration of *Hypsilophodon*, the lest and least specialised representative of the family, which w well known to us through the labours of Mr J. W. Hulke. is genus, which occurs in the Upper Wealden of England, the ral structure of the pelvis, as well as the pendant inner trochanter of the femur, resemble the corresponding elen *Camptosaurus;* and there are likewise four functional digi pes, of which the metatarsals are elongated; while the teet also occur in the hinder half of the premaxilla, are somewhat than those of *Iguanodon.* In conclusion, we may mention perfectly known forms which are evidently related to thi Of these, *Mochlodon,* from the Upper Greensand of A characterised by the absence of the channelled mandibu physis characteristic of typical forms; while *Craspedodon,* Upper Cretaceous of Belgium, is a very small Dinosau known by its teeth, which are more complex than *Iguanodon.*

FAMILY SCELIDOSAURIDÆ.—This family includes a gro markable Dinosaurs of medium dimensions, characterised clad in a stout dermal armour, usually consisting of detach and long spines, but sometimes taking the form of a solid completely covering the lumbar region. The rami of the are slender and tapering, but it is not known whether a p bone was present. The teeth (fig. 1061) have laterally flatt subtriangular crowns, with the borders carrying serrations or less obliquely or parallel to the long axis of the toot anterior and middle dorsal vertebræ differ from those *Iguanodontidæ* in having the articulation for the head of forming a "step" on the transverse process, as in Crocod not a facet on the arch; while there is also no fossa bet transverse process and the postzygapophysis. The limb-b solid and massive; the pre- and posta processes of the ilium very long; and t and ischium comparatively short. Th has an inner trochanter; the metata short and thick; and the pes, which was plantigrade, always has four functiona This family connects the *Iguanodontidæ* *Stegosauridæ,* and appears to be confine Old World, ranging from the Lias to t ceous.

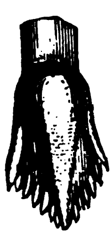


Fig. 1061.—Tooth of *Scelidosaurus Harrisoni;* from the Lower Lias of Dorsetshire. Twice natural size.

The type genus *Scelidosaurus,* of which is shown in fig. 1061, occurs in the Lo of Dorsetshire; and is well characterise strongly-marked serrations of the teeth, and the short an dermal spines or scutes. In the Wealden, the well-know *saurus* was a Dinosaur of considerable dimensions, cha by its enormous and laterally-compressed dermal spine which the skull and teeth are unfortunately still unknown detached teeth which have been provisionally referred to known to be Sauropodous. The anterior dorsal vertebræ have ell-marked hæmal ridge, which disappears in those later in the ries.

gnosaurus is founded upon a lower jaw from the Wealden, ich may pertain either to the last or the following genus. In *anthus*, of the same beds, we have a remarkable form, in ch the dermal armour constitutes a completely solid carapace er the whole of the dorsal aspect of the lumbar region, some of e component scutes being tuberculated, and others ridged; while ere was also a number of detached flattened spines somewhat like ose of *Hylæosaurus*, which probably formed a line in the dorsal egion. This peculiar type of carapace forcibly recalls that of the lyptodont Edentates. In the Chalk-Marl and Cambridge Green-nd, we find *Acanthopholis* with a dermal armour somewhat similar o that of *Scelidosaurus*, but with rather more complex teeth. The maller *Anoplosaurus*, of the Cambridge Greensand, was probably a losely allied, if not generically identical, form; while the equally mall *Syngonosaurus* and *Eucercosaurus*, of the same deposits, are istinguished by their compressed and carinated dorsal vertebræ, which resemble those of *Hylæosaurus*. Apparently allied to these rms is *Vectisaurus*, of the Wealden of the Isle of Wight, origi-ally referred to the *Iguanodontidæ*, but showing the "step" on the ransverse processes of the dorsal vertebræ characteristic of the resent family. *Priodontognathus*, founded on a fragment of jaw f unknown age, is probably referable to one of the preceding orms.

FAMILY STEGOSAURIDÆ.—This family is typically represented by he genus *Stegosaurus;* but before mentioning that form it will be onvenient to refer to two apparently allied Dinosaurs from the Karoo system of the Cape, both of which are very imperfectly nown, and may indicate a family connecting the present with the *guanodontidæ*. In *Euscelesaurus* (more correctly *Euscelidosaurus*), s the first of these forms is named, the limb-bones were solid, and he femur has a large inner trochanter, and approximates somewhat o that of the Iguanodonts. The tibia and fibula seem, however, o have been more like those of the *Stegosauridæ;* being anchylosed at their two extremities, and closely joined to the astragalus and alcaneum. The caudal vertebræ, belonging either to this or the next genus, are of an Iguanodont type. The genus *Orinosaurus* (*Orosaurus*) was founded upon a bone of a larger reptile, regarded by its describer as the distal end of a femur, but which is really the proximal end of a tibia. Although solid throughout, this bone re-sembles the tibia of *Iguanodon* in its expanded extremity, and thus suggests a transition between the *Iguanodontidæ* and *Stegosauridæ*.

The genus *Stegosaurus* was originally described from the Upper

Jurassic of North America; but it appears that certain forms from the Oxford and Kimeridge Clays of England, described at an earlier date under the preoccupied name of *Omosaurus*, are not entitled to generic distinction. These Dinosaurs agree with the *Scelidosauridæ* in the general structure of their teeth, and the possession of a dermal armour of scutes and spines, as well as in their solid limb-bones; but differ by the great height of the neural arches of the vertebræ, as well as by the circumstance that in the sacrum each arch is either chiefly or entirely supported by a single centrum, instead of by the adjacent portions of two centra, as in the preceding families. The skull (fig. 1062) shows many points of resemblance to that of *Iguanodon*, especially in the presence of a predentary bone; but it is lower and narrower, and thereby approximates to the Scelido…

Fig. 1062.—Left lateral view of skull of *Stegosaurus stenops*; from the Upper Jurassic … North America. One-quarter natural size. *a*, Nares; *b*, Orbit; *c*, Infratemporal fossa; *p*… Premaxilla; *m*, Maxilla; *n*, Nasal; *pf*, Prefrontal; *so*, Supraorbital; *fp*, Postfrontal; *po*, P… orbital; *l*, Lachrymal; *j*, Jugal; *q*, Quadrate; *sq*, Squamosal; *oc*, Occipital condyle; *ar*, Ar… cular; *sa*, Surangular; *an*, Angular; *s*, Splenial; *d*, Dentary; *pd*, Predentary. (After Mars…

saurian type. The Iguanodont resemblance is, however, so marke… as to forbid the reference of the forms with dermal armour to … separate suborder. The two rami of the caudal chevron-bones d… not unite superiorly. In the pelvis (fig. 1063) the ilium has a… enormous preacetabular process, and a very short postacetabula… portion; while the ischium and pubis are relatively short. In th… femur (fig. 1063) the inner trochanter is either very small o… absent; the metatarsals are very short and stout; and the fiv… digits of the plantigrade pes approximate in contour to those o… the Elephant. The tibia and fibula are suturally united together a… their extremities; and the former is completely joined to the astra… galus, and the latter to the calcaneum. Other peculiar features o… these remarkable reptiles are to be found in the structure of th…

nal in the sacrum. In the solid structure and general of the limb-bones, as well as in the relations of the tra to their arches, *Stegosaurus* approximates to the sub-ropoda; and thus shows how impossible it is to bring out relationships of animals in a linear classification. The ies indicates a reptile about two-thirds the dimensions of *n bernissartensis*. The American species have no inner r to the femur. The *iracodon* has been ap- an American Jurassic acterised by some modi- n the structure of the *Dystrophæus*, from the Arizona, appears to be less closely allied to the *idæ*.

Y CERATOPIDÆ.—This as been proposed for emarkable Cretaceous s allied to the preced- ly, but can only be pro- adopted. The type *Ceratops* (according to lentical with his *Poly-* of the Laramie Creta- f the United States, pair of large horn-cores kull, which are curiously se of the *Bovidæ*, and obably sheathed with The body was covered rmal scutes, which not bly had overlying horny ike those of Chelonians.

Fig. 1063.—The left pectoral and pelvic girdles and limbs of *Stegosaurus ungulatus*; from the Upper Jurassic of North America. $\frac{1}{30}$ natural size. *s*, Scapula; *c*, Coracoid; *h*, Humerus; *r*, Radius; *u*, Ulna; *i–v*, Phalangeals; *il*, Ilium; *is*, Ischium; *p*, *p*¹, Pubis; *f*, Femur; *t*, Tibia; *f*¹, Fibula; *a*, Astragalus; *c*, Calcaneum. (After Marsh.)

Upper Greensand of Austria there occur similar horn-like nce thought to have been attached to the body, and d as *Struthiosaurus* (*Cratæomus*), and it has yet to be hat the American types are generically distinct. A gigantic rm, from the Laramie, has been christened *Triceratops*, haracterised by the presence of an additional nasal horn- pported by the coalesced premaxillæ and an additional bone. The skull is stated to be upwards of six feet in the frontal horn-cores measuring some 22 inches. A e-like bone in the British Museum, from the Wealden, robably indicates an allied type.

Nodosaurus, of the Laramie, is a form more or less nearly allied to *Stegosaurus*, characterised by the completeness of the dermal armour, which consists of rows of rounded knobs, becoming small and quadrangular near the head. The skull is unknown.

Finally, the remarkable genus *Stenopelix*, from the German Wealden, should perhaps find a position somewhere in this neighbourhood, although it differs from all other members of this suborder by the presence of cavities in the centra of the caudal vertebræ.

SUBORDER 2. THEROPODA.—The suborder Theropoda holds in some respects a position intermediate between the Ornithopoda

Fig. 1064.—The left side of the pelvis of *Allosaurus fragilis*; from the Upper Jurassic of North America. One-twelfth natural size. *il*, Ilium; *is*, Ischium; *p*, Pubis; *a*, Acetabulum. (After Marsh.)

and the Sauropoda, although its members are more nearly allied to the latter; with which, as already mentioned, it has been proposed to group them, under the name of Saurischia. In many respects, such as the structure of the teeth, the form of the femur, the occasional presence of only two sacral vertebræ, and the form of the quadrate bone, certain members of this suborder nearer approximation than the Sauropoda to the general- codilia, although in their hollow limb-bones they agree higher Ornithopoda. All the forms were carnivorous. kull (fig. 1070) the premaxillæ are fur- hroughout with teeth, which are laterally sed (fig. 1065) and backwardly curved, chant edges, of which the posterior, and ly also the anterior, border is serrated; ctions of these serrations being generally t right angles to the axis of the crown. teeth are always implanted in distinct ; and the skull has a large preorbital va- g. 1070). The centra of all the vertebræ lowed internally; and their neural arches te by zygosphenes (diplosphenes) corre- g to those of the Squamata; while the fig. 1067) are much compressed laterally. The limb-bones have medullary cavities; and since the pectoral limb is much than the pelvic, it is probable that many forms were of habits, although some may have been quadrupedal. In vis (fig. 1064) the ilium is of great vertical depth, and has a reacetabular process; while the pubis is directed downwards rwards, and unites with its fellow in a long bony symphysis, s generally extended up the anterior face of the two bones; using them to have the appearance of an elongated Y, when om this aspect. Both the pubis and ischium are of a com- ely short and slender type of structure, and the latter usually obturator process like that of the Ornithopoda. The astra- s usually closely applied to the tibia, and not unfrequently ff a long flattened process lying on the anterior face of the bone, and thus resembles the condition found in young Birds before the anchylosis of the two bones has taken The metatarsals are elongated, and the feet digitigrade. In nus the number of the digits varies from four to five; while pes there may be either three or five. And in all cases their al phalangeals are furnished with curved claws, which in the are very long and prehensile, and were apparently adapted seizure and retention of the living prey.

Fig. 1065.—Lateral aspect of a tooth of *Megalosaurus Bucklandi*; from the Stonesfield Slate. One-third natural size.

ay further be observed that while the cervical vertebræ are ntly shorter than the dorsals, as in the Ornithopoda, yet they netimes longer, like those of the Sauropoda; while the ver- arches in the sacrum are occasionally supported by single as in the latter. Finally, the femur, which may be either hat longer or shorter than the tibia, is generally of a more dilian type—especially shown in its flattened head—than in

any other Dinosaurs, although it has a distinct inner tro
In all cases the dorsal vertebræ are amphicœlous.

FAMILY ANCHISAURIDÆ.—The least specialised forms c
ing this family, of which the name must be considered pro

Fig. 1066.—Outer aspect of the crown of a tooth of *Thecodontosaurus platyodon*; from the Lower Keuper near Bristol.

are mainly known from beds of Triassic a
are typically represented by the North A
genus *Anchisaurus* (*Amphisaurus*). The
vertebræ are amphicœlous; the pubes are
rod-like bones; and there are five digits
the manus and the pes. The teeth (fig.
usually have comparatively thick and short
with a slightly convex posterior borde
more or less oblique serrations, which occ
whole of both borders. *Thecodontosaurus*
in the Lower Keuper near Bristol; the
the type species being much smaller than
figured in the woodcut. *Anchisaurus* (which, according to
sor Marsh, is identical with a form described at an earlier
der the preoccupied name *Megadactylus*) occurs in the reput

Fig. 1067.—Lateral and inferior aspects of the centrum of a dorsal vertebra of *Massospondylus carinatus*; from the Karoo system of Basutoland. One-half natural size.

of the United States; but no e
has yet been presented to sh
it differs from the Europear
The writer last quoted include
family the American Triassic
Bathygnathus and *Clepsysaur*
of which are still very im
known. Here may be mentio
genus *Massospondylus*, from th
system of South Africa and th
stage of the Gondwana system
of which a tooth is shown in
(p. 1049), and the centrum of
vertebra in fig. 1067. These
approximate to those of *Megai*
and have a fusiform internal c

Finally, it is highly probal
an amphicœlous cervical vert
tained from beds of unknown
zoic age in Bathurst Island
America, and described un
name of *Arctosaurus*, indi
Dinosaur more or less closel
to the present or following family. This vertebra agrees
mately in size with that of *Calamospondylus* (fig. 1071), but
cervical ribs and a neural spine; the length and curvature

›eing indicative of a long and arched neck. The occur- a Dinosaur so far north is of extreme interest, as serving to genera common to the Old and New Worlds may have from the one hemisphere to the other.

y MEGALOSAURIDÆ.—In this family the cervical vertebræ n known) shorter than the dorsals, and may be either r opisthocœlous; while the dorsals often have prominent the base of the arches, between which are deep pits; the centra, as in the last family, having a fusiform internal In the pelvic limb of the type genus, the femur is of a re- y Crocodilian type, and is longer than the tibia. The crowns eth (fig. 1065) are more or less tall, and much compressed, posterior border distinctly concave, and the serrations, re nearly at right angles to the axis of the crown, usually at the lower part of the anterior border. In the Lower of England we meet with *Palæosaurus* (with which *Cladyodon* me deposits may be identical), of which only detached teeth vn. In the Upper Keuper of the Continent there occurs paratively generalised genus *Zanclodon* (*Teratosaurus*), which probably iden- h *Plateosaurus*, case the latter ould be adopt- e serrations on rior borders of ns of the teeth nearly to the e cervical ver- are amphicœ- ere are but two in the sacrum; astragalus does off a process

Fig. 1068.—Fragment of the mandible of *Epicampodon indicus*; from the Panchet beds of the Gondwanas. Three times natural size. A, Lateral; B, Posterior aspect; C, Transverse section of tooth. (After Huxley.)

g on to the anterior surface of the tibia. One of the was fully as large as *Megalosaurus*, and the genus was represented in the Lower Lias of Dorsetshire. The small *odon* (*Ankistrodon*), of the Panchet stage of the Indian nas, has teeth (fig. 1068) of a Megalosauroid type, in which tions are totally absent from the anterior border, and do nd to the base of the posterior border.

ype genus *Megalosaurus* has been rendered classic through urs of the late Professors Buckland and Phillips, and affords lent and instructive instance of the gradual restoration of eton of an extinct and uncouth form from more or less tary remains. In Europe this genus ranges from the Stonesfield Slate (Lower Jurassic) of England to the topmost Cre of Maastricht in Holland; and has also been recorded fr Upper Cretaceous of Southern India. There is good evid the existence of two species in the Wealden. An attem restoration of the skeleton of the type species is shown accompanying woodcut. The North American *Allosaurus* (o the pelvis is represented in fig. 1064) appears to be a allied form of Upper Jurassic age. The nearly entire sk of the latter and other American forms have shown that very excusable errors were made in the restoration imperfect elements of the skeleton of the English gen it is quite evident that the skull of *Megalosaurus* mu had an inferior temporal and that it approximate or less closely to that of *saurus* (fig. 1070), alth bony processes of th may have been wanting. teeth (fig. 1065) the s on the anterior borde

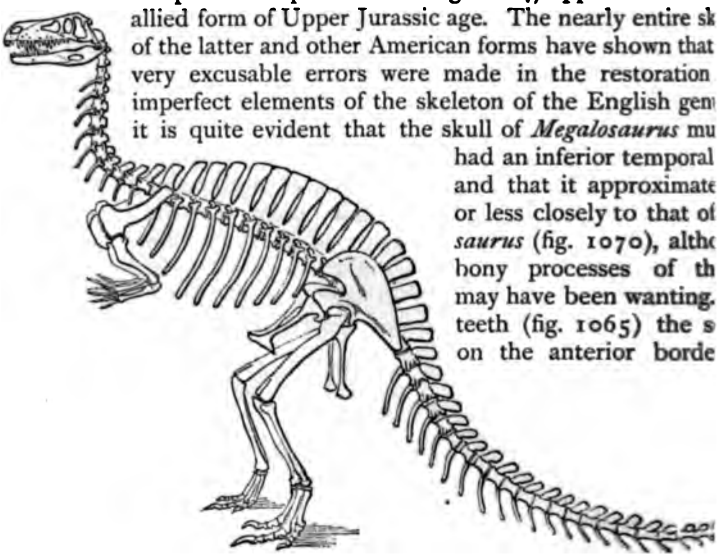


Fig. 1069.—Restoration of the skeleton of *Megalosaurus Bucklandi*; from the St Slate. Greatly reduced.

some cases confined to the upper half of the crown, but i extended nearly throughout. Typically there are five vert the sacrum; the cervical vertebræ are opisthocœlous; the a has a process ascending on to the tibia; and there were thr in the pes and probably four in the manus. In the North A *Creosaurus* we have an allied Upper Jurassic genus, in wh postcervical vertebræ have very deep depressions on the sides centra; and there are but two sacral vetebræ. In *Cerat* of the Upper Jurassic of North America, the skull (fig. 1 remarkable for carrying a single bony protuberance beh terminal nares, and a pair of similar protuberances directl vance of the orbits; while the mandible has a lateral vac that of the Crocodilia. Professor Marsh believes that t tuberances on the skull supported horns. In the type speci three pelvic bones and the metatarsals were respectively anc

; but this may perhaps be due to a pathological peculiarity dividual. This genus is regarded by its describer as the distinct family—the *Ceratosauridæ*. Here may be men- small and imperfectly known Dinosaur from the Wealden h the name *Aristosuchus* has been proposed. The type comprises the sacrum and part of the pelvis. It is con- by its describer that the sacrum includes five vertebræ, e pelvic bones, which have a long ventral symphysis, were y described as pubes, although it has been subsequently d that they may be ischia. The dorsal vertebræ referred orm by Sir R. Owen have a fusiform internal cavity in the , but it has been recently suggested that this reference is

—Left lateral view of skull of *Ceratosaurus nasicornis*; from the Upper Jurassic America. One-sixth natural size. *a*, Nares; *b*, Bony prominence; *c*, Preorbital Orbit; *e*, Infratemporal fossa; *f*, Mandibular vacuity; *t*, Transverse bone. (After

t, and that this genus may have had dorsal vertebræ like the *Cœluridæ*, in which case this form may be referable *rus*, in which, indeed, it has been placed by Professor

LY COMPSOGNATHIDÆ.—This family is represented by the *Compsognathus* of the Lower Kimeridgian Limestone of and the allied or identical *Hallopus* of the Upper Jurassic h America. In the typical genus—known only by a single —the cervical vertebræ are opisthocœlous, and much longer amphicœlous dorsals, and have free cervical ribs. In the he femur is shorter than the tibia, and both the manus and pes have only three functional digits; the astragalus being cl applied to the tibia. The teeth and pelvis approximate to Megalosaurian type. *Compsognathus* was about two feet in length; and undoubtedly hopped on its pelvic limbs, after manner of a bird. *Hallopus* is one of the few Dinosaurs with two sacral vertebræ; the number of those of *Compsognathus* is unknown.

FAMILY CŒLURIDÆ.—This family is represented by comparati small forms, ranging in size from five or six to about twelve in length. They are characterised by the vertebræ and ribs b completely honeycombed by cavities, communicating with a aperture on the side of the centrum. The cervical vertebræ 1071) are typically longer than the dorsals, and have the anchylosed to the arch and centrum, and the neural spine red to a mere ridge. The limb-bones are hollow, and the pelvis

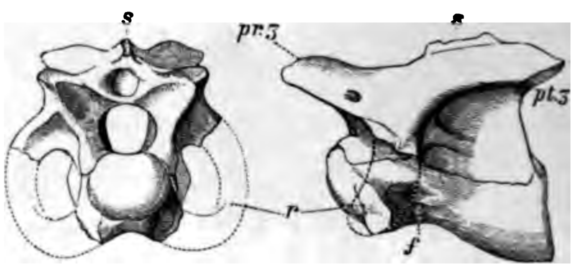


Fig. 1071.—Anterior and left lateral aspects of a cervical vertebra of *Calamospondylus* from the Wealden of the Isle of Wight. Two-thirds natural size. *prz*, Prezygapophysi Postzygapophysis; *r*, Rib (restored); *f*, Pneumatic foramen; *s*, Neural spine.

the ordinary Theropodous type, with a very long pubic symp The type genus *Cœlurus*, typically from the Upper Jurassi America, but also occurring in the English Wealden, has cervical vertebræ greatly elongated, the first few being op and the remainder amphicœlous. In *Calamospondylus* (fig. 1 the cervicals were shorter, and were probably all opisthocœl the one known species being from the English Wealden. fessor Cope includes in this family other small Dinosaurs the Trias of North America, which he identifies with *Tan phæus*, originally described on the evidence of extremely elon caudal vertebræ from the German Muschelkalk, once referr the Sauropterygia. In these forms all the cervical vertebræ amphicœlous; and the femur has an inner trochanter. *dactylus*, which Professor Cope regards as identical with forms, is, as already mentioned, identified by Professor Marsh *Anchisaurus*.

SUBORDER 3. SAUROPODA.—With the third and last subord n the consideration of the largest known Dinosaurs, and ch make so many marked approximations to the more d Crocodilia as to show how close is the relationship hat order and the Dinosauria.[1] The skull (fig. 1076) h that of the Theropoda in having the premaxillæ com-othed, and also in the presence of a large preorbital but the external nares formed long slits in the fore part of as in Ornithosaurs and Birds. The teeth are invariably tinct sockets and are of a spatulate form, without marginal (fig. 1072). The sternal bones are ovate. All the ver-advance of the sacrum, and sometimes those of that region e a large vacuity side of the cen-nmunicating with f internal cavities, ve a honeycomb-ture to the whole This affords a tion of strength

Fig. 1072.—Outer side of a tooth of *Morosaurus grandis*; from the Upper Jurassic of North America. One-half natural size. (After Marsh.)

tness in the massive supports necessarily required for the s, limbs, and muscles, which could not have been attained ther manner. All the anterior vertebræ are opisthocœlous; he cervical region the ribs are anchylosed to the vertebræ, ave no neural spines, and are longer than the dorsals; while es of the latter are laterally expanded; and in the sacrum ntrum supports its own arch. The limb bones are solid; e the pectoral limb is not much shorter than the pelvic, it that these Reptiles were habitually quadrupedal. All the e plantigrade, and furnished with five digits; those of the g terminated by large curved claws. The ilium (fig. 1073) pper border only moderately arched and its postacetabular short; while the pubis (fig. 1073), which is directed down-nd forwards, is stout with a comparatively small distal expan-ere it unites by a cartilaginous symphysis with its fellow of site side. The ischium (fig. 1073) is likewise a stout bone with that of the Crocodilia in the absence of an obturator and the two ischia have a peculiar incurving of their distal y where they meet in a symphysis.

be observed that in the lateral views of the pelvis shown in the where the bones are drawn more or less nearly in a vertical is impossible to give a true idea of the peculiar contour of the remity of the pubis and ischium. These bones are really con-n above downwards on the outer (figured) aspect, and convex on

[1] sor Cope would include the Sauropodous Dinosaurs in the Crocodilia.

the inner aspect; and owing to a confusion between the proper inner and outer sides of the English specimens, only recently cleared up, it has been considered by some palæontologists that there was an essential difference between the structure of the pelvis of the English and American forms.

The femur in its straight shaft and absence of an inner trochanter likewise resembles to a considerable extent that of the Crocodilia,

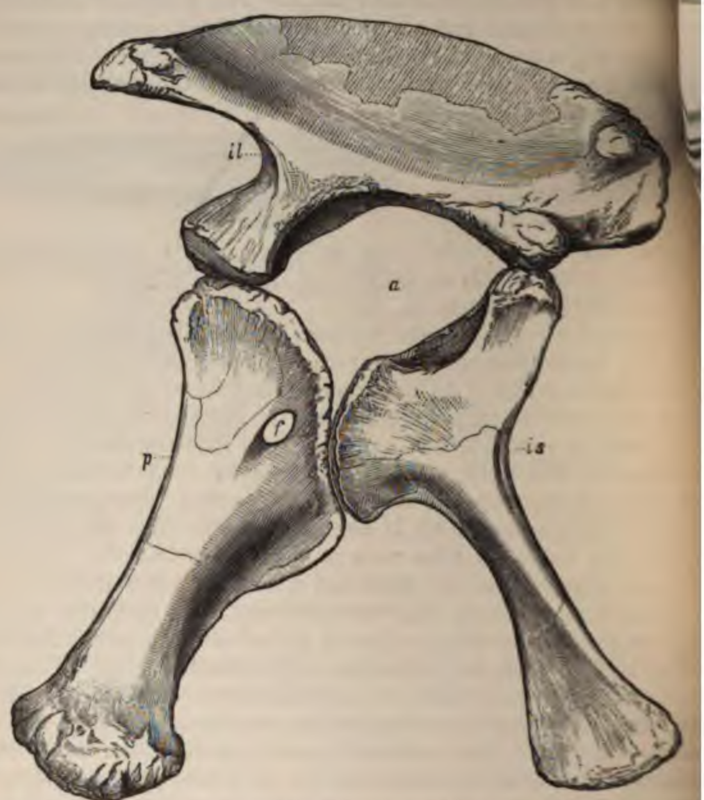
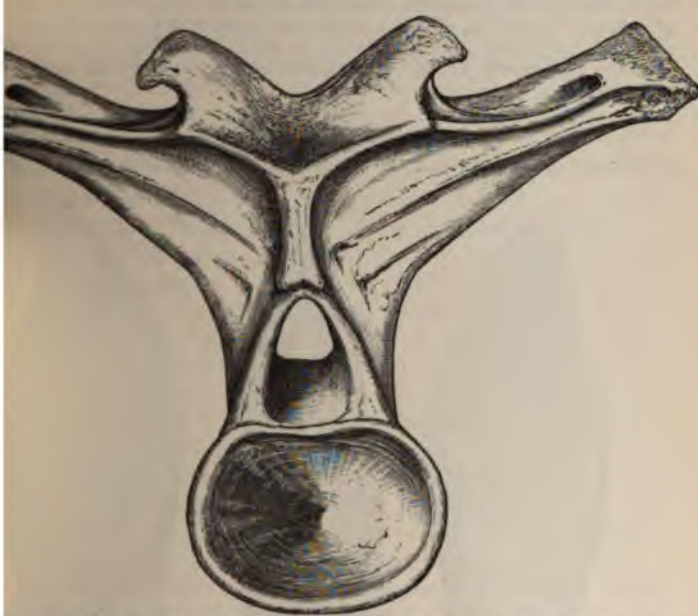


Fig. 1073.—The left side of the pelvis of *Brontosaurus excelsus*; from the Upper Jurassic of North America. One-sixteenth natural size. *a*, Acetabulum; *il*, Ilium; *is*, Ischium; *p*, Pubis; *f*, Foramen in do. (After Marsh.)

although its head is not laterally compressed to the same extent, nor placed so obliquely to the distal condyles.

In time this suborder ranges from the Upper Trias to the Cretaceous, and it is especially well represented in the Kimeridge Clay and Wealden of Europe.

LY ATLANTOSAURIDÆ.—This name may be provisionally l for a family which is represented by the genera *Atlanto-* *Apatosaurus*, and *Brontosaurus*, of the Upper Jurassic of America, as well as by allied European types. In these huge he ischium (fig. 1073) is directed downwards, and its shaft is nd not bent upon itself; while the humerus is comparatively ; and the chevrons of the caudal vertebræ have their superior ities united. The teeth have the summit of the crown not



74.—Posterior view of an anterior dorsal vertebra of *Camarasaurus supremus*; from the Upper Jurassic of North America. Reduced. (After Cope.)

incurved. Apparently closely allied to, if not identical with, of the above-mentioned genera are *Amphicœlias* and *Camara-* of the same formations. An anterior dorsal vertebra of ter genus is represented in the accompanying woodcut; this ra is transitional between the cervicals and later dorsals, the spine of the latter being absent.

essor Marsh estimates the total length of *Brontosaurus* at upwards feet, and its weight at more than twenty tons; and *Pelorosaurus*, English Wealden, must have been fully equal to these dimensions. pect of the former, the learned American palæontologist observes, the animal at times assumed a more erect position than is repre- l in the restoration is probable, but locomotion on the posterior limbs alone was hardly possible. The head was remarkably small. The neck was long, and, considering its proportions, flexible; and was the lightest portion of the vertebral column. The body was quite short, and the abdominal cavity of moderate size. . . . Each footprint must have been about a square yard in extent. The tail was large, and nearly all the bones were solid. The diminutive head will first attract attention, as it is smaller in proportion to the body than in any vertebrate hitherto known. The entire skull is less in diameter or actual weight than the fourth or fifth cervical vertebra. . . . The very small head and brain, and slender neural cord, indicate a stupid, slow-moving reptile. The beast was wholly without offensive or defensive weapons, or dermal armature. In habits, *Brontosaurus* was more or less amphibious, and its food was probably aquatic plants or other succulent vegetation. The remains are usually found in localities where the animals had evidently become mired."

Of still more stupendous bulk is *Atlantosaurus immanis*, the femur of which has the enormous length of six feet two inches, and thus

Fig. 1075.—Inner (*a*), outer (*b*), and profile (*c*) views of a tooth of *Hoplosaurus armatus*; from the Wealden of the Isle of Wight. (After Wright.)

indicates one of the largest land animals yet known; the only form which could possibly have exceeded it being the Cretaceous *Tricer-atops* mentioned above. It is by no means clear that all the n types are generically distinct from those to be now ed.

ay now proceed to the consideration of certain European s which from their more or less close alliance to the pre-rms appear to belong to the same family, although opinions ntrary have been expressed. It may be observed in this on that the study of all the European Sauropoda is beset ost insurmountable difficulties owing to the circumstance ly all the specimens are disassociated, and that genera and ave been named on the evidence of single teeth, vertebræ, of the limbs or limb-girdles, so as not to admit of com-with one another. Moreover, the unwieldy bulk of the s themselves is a bar to an exact comparison, even when strictly comparable one with another.

ooth from the Wealden of the Isle of Wight, represented atural size in fig. 1075, has been made the type of the *oplosaurus* (*Oplosaurus*), and it appears almost certain that and dorsal vertebræ, and a pelvis from the same deposits, d under the names of *Ornithopsis Hulkei* and *O. eucamerotus*, able to the same form. These remains indicate a Reptile derably smaller dimensions than *Brontosaurus*, having a hich approximates in structure to that of *Atlantosaurus*. ium, which has the downward direction characteristic of ent family, has a length of 27 inches, and is comparatively proportion to the pubis. The genus *Pelorosaurus* is typified e humerus from the Wealden of Sussex, measuring some s in length, which would appear far too large for the type of *Hoplosaurus*.[1] A slightly larger humerus from the Kim-Clay, originally described as *Cetiosaurus humerocristatus*, generically inseparable from *Pelorosaurus*, and its owner ll probability very closely allied to an equally large form Oxford Clay, described upon the evidence of the pelvis as sis *Leedsi*. Of the latter the lumbar and caudal vertebræ known, and approximate closely, both in size and contour, of *Brontosaurus*, the lumbars having a diameter of nearly s across the centrum. In the pelvis the ischium measures 6 inches in length, and is also narrower in proportion to the an in *Hoplosaurus*—differences which, coupled with others, bably be regarded as of generic value. Referring all these least provisionally, to *Pelorosaurus*, it would appear that this cludes very large *Dinosaurs* closely allied both in vertebral ic characters, as well as in point of size, to *Brontosaurus*, al-

[1] are the proportions of this bone and of the ischium mentioned below corresponding dimensions of other Dinosaurs given in the table on the .

though it is probable that the humerus was relatively longer. Te... from the Kimeridgian of Boulogne, upon the evidence of which th... genus *Neosodon* was founded, but which were subsequently identi... with American forms described as *Caulodon*, are probably referable... to the same species. Small vertebræ from the Kimeridge Clay of... Swindon, upon which the genus *Bothriospondylus* was established... may perhaps be referable to a very young individual of *Pelorosaurus humerocristatus*; while a comparatively small humerus from the... same deposits, originally described under the preoccupied name of *Ischyrosaurus*, may indicate a smaller species of the same genus. Finally, of the Kimeridgian remains described as *Gigantosaurus*, while some may be referable to *P. humerocristatus*, a sacral vertebra may belong to the smaller *P. Manseli* above mentioned.

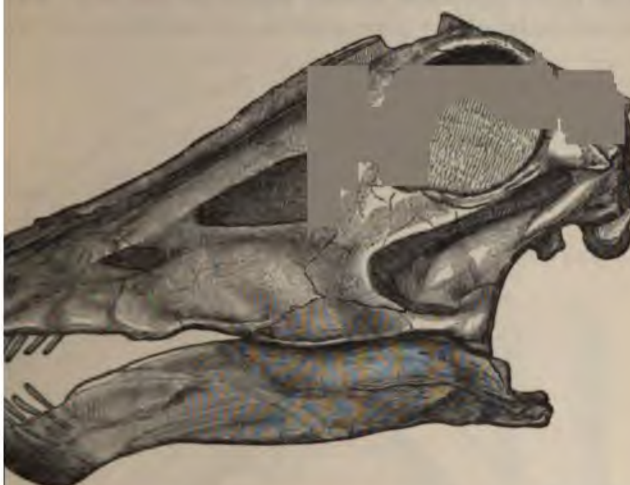
The following table gives the dimensions of some of the bones of certain of the above-mentioned forms, together with those of others noticed below under the head of the *Cetiosauridæ*:—

	Atlantosaurus.	*Brontosaurus.*	*Pelorosaurus Conybeari.*	*Pelorosaurus humerocristatus and Leedsi.*	*Hoplosaurus.*	*Morosaurus (type).*	*Cetiosaurus.*	[illegible]
Length of scapula . .	...	60	...	...	...	45	54	...
" humerus . .	...	50?	54	57	...	36	51.5	24
" ischium . .	...	40	...	35.5	27	30.5	39?	...
" femur . .	74	70?	...	...	...	46	64	...
Width of dorsal centrum .	...	13	...	...	8.5	...	...	6
" lumbar " .	...	14	...	11.5[1]	...	...	...	7
" caudal " .	...	12	...	...	...	...	?10	7

FAMILY DIPLODOCIDÆ.—The genus *Diplodocus*, from the Upper Jurassic of North America, is typically represented by a species of smaller size than many of the preceding forms, and is regarded by Professor Marsh as the type of a family. It was originally considered that the external nares were single, and situated at the top of the skull between the orbits (fig. 1076); but it now appears that they really formed long narrow slits between the premaxillæ, nasals

[1] Caudal vertebræ of a larger individual are nearly equal in size to those of *Brontosaurus*.

llæ, after the fashion obtaining in Pterodactyles and Birds. probable that a similar arrangement exists in the other of the suborder. It will be observed from the figure ugal bifurcates posteriorly to form the anterior and inferior of the orbit; while the quadratojugal joins the maxilla he intervention of the jugal, which is thrust up. These features are repeated, as will be noticed below, in one the Ornithosauria. The pelvis is of the general type of



—Left lateral aspect of the skull of *Diplodocus longus*; from the Upper Jurassic of ica. One-sixth natural size. The position of the nares at the top of the skull is After Marsh.)

he last family; but the distal extremity of the ischium is nded.

Y CETIOSAURIDÆ.—This family is typically represented by ish genus *Cetiosaurus*, which, so far as can be determined characters of the scapula and pelvis, appears to be so ated to the American *Morosaurus* that there seems every r including the latter in the same family. *Cetiosaurus* pically in the Lower Jurassic Great Oolite, and Forest- f Oxfordshire and Northamptonshire, where we meet with *C. oxoniensis*. Comparatively small teeth from the same described under the earlier name of *Cardiodon rugulosus*, e same general type as those of *Hoplosaurus*, but have rela- aller crowns, with a more incurved summit, and are clearly from the last-named genus. Professor Phillips referred this type to *C. oxoniensis*, but from their small size they would agree better with a dorsal vertebra from the same dep subsequently described as *Bothriospondylus robustus*. This vert is somewhat longer than the dorsals of *C. oxoniensis*, but need be generically distinct. In *Cetiosaurus* the caudal vertebræ h no distinct postzygapophyses, and articulate by two facets with chevrons, of which the upper extremities are not united, as in c codiles. The scapula is much expanded at its distal extremity, the humerus, though long, is wider and shorter than in the Eu pean forms mentioned among the *Atlantosauridæ*. The isch appears to be of the same general type as that of *Morosaurus* (

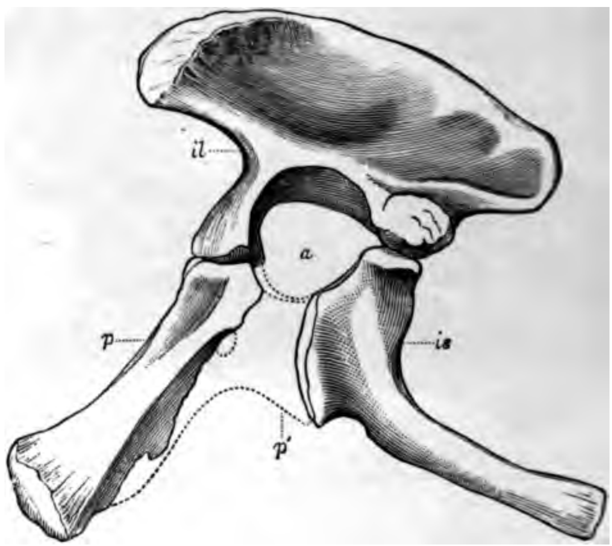


Fig. 1077.—The left side of the pelvis of *Morosaurus grandis*; from the Upper Juras North America. One-sixteenth natural size. *a*, Acetabulum; *il*, Ilium; *is*, Ischium; Pubis. (After Marsh.)

1077), in which the shaft is bent backwards and has no di expansion, while the symphysis does not extend to the extrem thus causing the middle of the acetabular part to be far above axis of the shaft.

The typical species of *Cetiosaurus* is comparatively well known thro the labours of the late Professor Phillips. This huge reptile was perh somewhat smaller than *Pelorosaurus*; and it was inferred from the w ossified extremities of the limb-bones, the free projection of the hea the femur into the acetabulum, and the large terminal claws, that creature was of terrestrial or subaquatic habits, and that it proba dwelt on the banks of lakes or rivers among brakes of ferns, cycads, conifers. From the structure of a tooth (*Cardiodon*) found in the sa

Cetiosaur was inferred to have been of herbivorous habits. ırkably these conclusions have been confirmed by the discovery ed American forms, is now a matter of history.

Wealden sacral and caudal vertebræ of the general type of *Cetiosaurus*, described under the name of *Cetiosaurus* dicate a smaller form than *Hoplosaurus*. It is probable rsal vertebra from the same deposits, described as *Bothrio- elongatus*, as well as a humerus and other bones of the limb, to which the name *Morosaurus Becklesi* has been ıre referable to the same form, which would appear to be ly distinct from *Cetiosaurus*, and may be known as *Moro- evis*. The dimensions of some of the bones are given in on p. 1176. An ilium, from the same beds, closely s that of the American genus, and probably belongs to form. In North America, *Morosaurus* and the small *lus* are characteristic of the Upper Jurassic. The dorsal of the latter are relatively elongated, and do not exceed es in length; those of one species being remarkable for y low neural arches. Small teeth Wealden (fig. 1078), once referred to *ırus*, probably belong to a species of *lus*. These teeth are less spoon-shaped, roximate more to a compressed cone se of *Morosaurus* (fig. 1072); and the *eurocœlus* includes the smallest repre- s of the suborder. The pelvis of *rus* is shown in fig. 1077; the teeth 2), although considerably larger than *Cardiodon* and *Pleurocœlus*, exhibit e incurving of the crown.

Fig. 1078. — Outer and profile views of a tooth of *Pleurocœlus valdensis*; from the Wealden.

e preceding forms the centra of the ertebræ are amphicœlous; but *Titanosaurus*, originally de- from the Cretaceous of India, and subsequently found in lish Wealden and Upper Greensand, has procœlous centra vertebræ. The femur of this genus indicates an animal as *Cetiosaurus*.

ıins of other Cretaceous Sauropoda have received distinct names, but some of them may be identical with the above- ed types. Thus we have *Dinodocus* based on broken bones Lower Greensand of Kent; and *Æpysaurus* founded on a from the French Cretaceous. *Macrurosaurus*, from the dge Greensand, is a smaller form, with imperfectly procœlous vertebræ. Finally, the name *Thecospondylus* has been ap- a specimen from the Wealden, of which even the subordinal cannot be determined, although it has been suggested,

without sufficient foundation, that it indicates a form allie
Cœlurus.

ORDER IX. CROCODILIA.—The Crocodiles of the present are well-known, lacertiform Reptiles inhabiting the lakes, r and marshes of the warmer regions of the globe; and ar largest existing representatives of the entire class. If we had these existing and specialised forms to deal with, we should no difficulty in giving a concise definition which would separat order to which they belong from the Dinosauria. There c however, in the Trias a number of generalised forms whic proximate so closely to the latter order as to render such defi extremely difficult; and it is quite possible that some of the u mentioned characters are not applicable to the first suborder. order is sometimes known as the Emydosauria.

In all the forms the limbs and body (fig. 1079) are of a l form type, the former being very short, and the latter lon

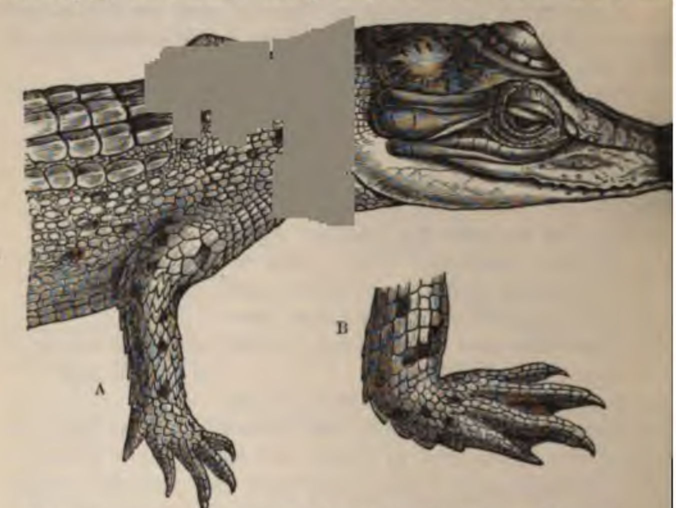


Fig. 1079.—Head and fore-part of the body (A) and hind foot (B) of *Crocodilus por* from Madras. Much reduced. (After Günther.)

carried close to the ground; while the tail is relatively long. the exception of a few later Jurassic forms, the dorsal aspect body carries a dermal armour of articulating or imbricating scutes, arranged in two or more longitudinal rows (fig. 1079 marked on their outer surface by a series of deep pits. In c cases there may also be an armour of similar type developed ventral surface of the body. The centra of the vertebræ are amphi- or procœlous, and the neuro-central suture is pers e cervical vertebræ have double pedunculate costal tubercles, ated one on the centrum and the other on the arch; and the vical ribs have long processes projecting anteriorly and pos-orly, which completely prevent the head from being turned ways. In the dorsal region usually the four anterior vertebræ e the transverse process for the articulation of the tubercle of rib placed on the arch, while there is a lower process, or rib-et, on the centrum for the capitulum of the rib; but posteriorly s rib-facet rises on to the arch, and in the middle dorsals forms kind of "step" on the transverse process, while still more pos-orly it merges with the tubercular facet. The dorsal ribs have cinate processes, like those of Birds; and the chevron-bones of caudal region usually have the upper limbs of the Y not united

Fig. 1080.—Oblique left lateral and superior view of the skull of *Crocodilus palustris*; India. Much reduced. The small paired apertures to the right are the supratemporal fossæ, in ad-ance of which are the orbits communicating posteriorly with the infratemporal fossæ.

y bone. Normally the sacrum has but two vertebræ.[1] The skull fig. 1080) is relatively large in proportion to the body, and is sually much depressed; its component bones are firmly united, nd generally have a characteristic sculpture on their external urface. The palatines and pterygoids unite in the middle line, nd thus close the palate; and very frequently one or both of these aired bones develop inferior plates, which meet beneath the narial assages (fig. 1089). The quadrate is tightly wedged in among he adjacent bones; the tympanic cavities usually communicate with he mouth by three eustachian canals; the mandibular symphysis nites by suture; and there are generally no ossifications in the clerotic of the eyeball. There is almost invariably a lateral vacuity n the mandible (fig. 1093). The teeth are always either pointed

[1] As an abnormality three sacrals may be present.

and subconical, or laterally compressed. In the sternal re sternum itself is cartilaginous; and there is a bony intercla generally no clavicle. pelvis (fig. 1081) the short and deep, without preacetabular or pubic p the ischium is stout, and of obturator process; w pubis[1] is directed do and forwards, and is fr excluded from the acet In regard to the pector and limbs, it will suffic that all the bones ar that the coracoid has nelle, and may be eith or long; that in the and femur the heads perfectly differentiated, the latter being compres placed very obliquely to the plane of the condyles; while of the femur has no inner trochanter. Moreover, the tibi cnemial crest at its proximal extremity. The habits of members of the order are quadrupedal; and the feet (fig are plantigrade, those of the hind limbs being partially web

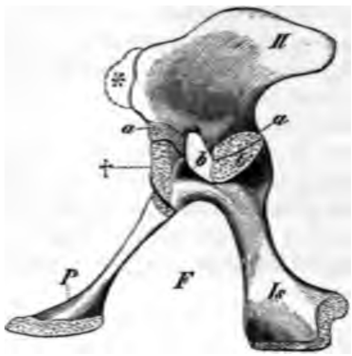


Fig. 1081.—Left side of the pelvis of a young *Alligator*. *Il*, Ilium; *Is*, Ischium; *P*, Pubis; *a*, *b*, *b*, Acetabulum, with its vacuity; *F*, Obturator notch; †, *, Cartilaginous processes of the ischium and ilium.

The existing Crocodiles present many peculiarities in the soft parts; but since we do not know whether the same occurred in the generalised fossil forms, and cannot comp with extinct orders, it is unnecessary to allude to them furt

This order is peculiarly interesting, not only as contai on y existing members of the Archosaurian branch; but a it affords a beautiful example of the gradual evolution of sp characters as we ascend in the geological scale.

SUBORDER I. AËTOSAURIA.—This provisional suborder but a single family, which Dr Baur places in the Crocodilia, Professor Cope regards it as more nearly related to the I cephalia, to which it perhaps belongs.

FAMILY AËTOSAURIDÆ.—This family is typically repres the genus *Aëtosaurus*, of the Upper Trias of Würtemberg form with Crocodilian armour and limbs, but with the m much elongated, and approaching in many points of its org to the Theropodous Dinosauria, to which Professor Marsh

[1] It has been suggested that the bone termed pubis in the Eusuchia prepubis.

rly related. *Typothorax*, with pitted scutes adherent to the in allied form from the reputed Trias of North America; rofessor Cope regards as foreshadowing in its dermal skeleton pace of the Chelonia.

RDER 2. PARASUCHIA.—This extremely generalised suborder ned to the Trias, or strata of approximately equivalent age. racterised by the absence of descending palatal plates de- from the roof of the mouth, so that the posterior nares (fig. pen directly into the latter, without the intervention of a ry passage. The vomers are seen on the palate; the middle the three eustachian canals appears to be wanting[1]; the nares are placed in the middle of the cranium; and the llæ have typically some twenty-one teeth, and are produced ong rostrum. A clavicle was probably present, the coracoid rt and rounded like that of the Dinosauria; while the pubis, e latter, takes a share in the formation of the acetabulum; h foot was probably furnished with five digits. The centra vertebræ are amphicœlous; and the dorsal scutes have a ridge, and form only two longitudinal rows; while those of tral buckler (when present) are arranged in not more than such rows, and each scute consists of a single bone. This liffers very widely from the true Crocodiles, and Dr Baur pears to regard it as a distinct order, under the name of uria.

LY PHYTOSAURIDÆ.—This family is best known by the type *Phytosaurus* (*Belodon*); originally described from the Keuper,

2.—Right lateral view of the skull of *Phytosaurus cylindricodon*; from the Keuper of rg. Much reduced. The vacuities in the cranium are the preorbital, the orbit, and mporal fossa. (After Meyer.)

er Trias of Würtemberg, but subsequently found in beds of imately equivalent age in both India and North America. skull (figs. 1082, 1083) the orbit is separated by a bony bar he infratemporal fossa; there is a large preorbital vacuity,

[1] According to Dr Koken.

and the supratemporal fossa is exceedingly small. The nasals reached the premaxillæ and completely surrounded the nares—thus presenting a feature unknown in any other vertebrate; while the orbits were somewhat irregular in contour, and directed in part laterally, and in part frontally. The teeth are sharp and pointed

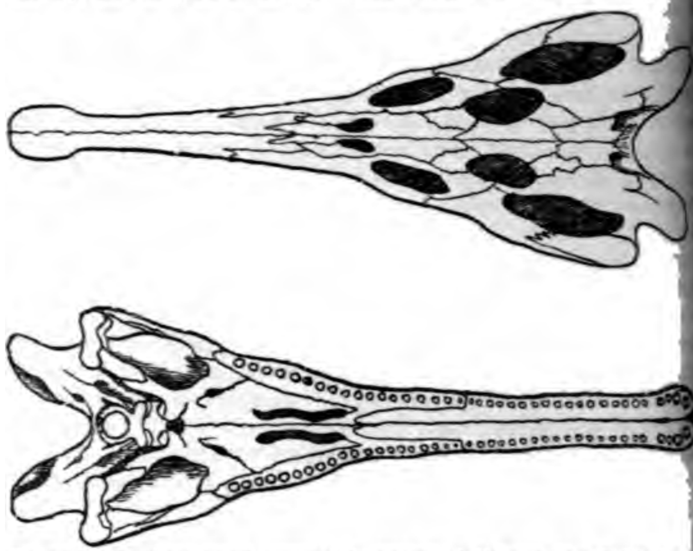


Fig. 1083.—Frontal and palatal aspects of the cranium of *Phytosaurus cylindricodon*. The anterior vacuities in the upper figure are the anterior nares, and the slits in the lower figure are the posterior nares. (After Meyer.)

with serrated antero-posterior ridges (carinæ); and in the anterior part of the jaw (fig. 1084) are subcircular in transverse section, but posteriorly are laterally compressed. There was no ventral armour. In the apparently nearly allied *Stagonolepis*, of the Upper Trias (Keuper) of Elginshire, there was, however, a well-developed ventral dermal armour; the teeth were blunt and swollen; and the pattern of the sculpture on the dorsal scutes was different. This genus was originally founded upon the evidence of these scutes, which were thought to have belonged to a Ganoid Fish. The name *Episcoposaurus* has been applied to a North American Triassic form which is regarded by Professor Cope as allied to *Phytosaurus*.

Fig. 1084.—Tooth of *Phytosaurus carolinensis*; from the Trias of South Carolina. Reduced.

FAMILY PARASUCHIDÆ.—The single genus *Parasuchus* occurs in the same lower Mesozoic horizon (Maleri beds) in India which

post-Triassic Crocodilia. These were, indeed, originally into two suborders, but subsequent researches have shown y are so closely connected as to render such division inad-
In all these forms the premaxillæ, maxillæ, and palatines inferior palatal plates meeting in the middle line beneath ial passage, and thus completely separating the latter from ith, and causing the formation of secondary posterior nares, n some instances are situated immediately behind the pala- ut in others (as in the figure of *Crocodilus* given on page owing to the development of similar plates by the pterygoids, the latter bones. The object of this peculiar arrangement able these animals to drown their prey by holding it in their iouths under water, which is thus entirely prevented from ; the air passages. A gradual evolution of this structural can be traced from the last suborder, where it is entirely , to the generalised, and thence to the most specialised, rs of this division. Other characteristic features are found terminally-situated, and usually undivided, nares; in the earance of the vomers on the palate; in the bony middle ian canal; and the presence of not more than four or th in the premaxillæ. There is no clavicle; the coracoid n elongated; the pubis is entirely excluded from the ace- n (fig. 1081); and there are five digits in the manus and four pes (fig. 1079). This suborder may be divided into two ccording to the development or non-development of palatal y the pterygoids, and the form of the vertebræ.

occurrence in all the groups of the Eusuchia of long-jawed and wed forms is so suggestive of the direct origin of the existing s from long-jawed Mesozoic types, and of the Crocodiles and Alli- rom short-jawed forms of the same epoch, that Dr Koken adopts

portion, but may be single; while in the transverse rows o
buckler the scutes always imbricate anteriorly, but in the po
part usually articulate by suture; each scute being invariably
posed of a single piece of bone.

It may be incidentally mentioned here that while in the a
region of the ventral buckler of all Crocodiles the component
of each transverse row articulate together by suture with tho
either side, yet, as will be gathered from the foregoing cha
in the posterior portion of the same buckler in the present
the articulation of the different transverse rows with one a
may be either by suture, or by imbricating like the tiles on a
The present series ranges in time from the Lias to the
and Middle Cretaceous, and is especially characteristic
European strata.

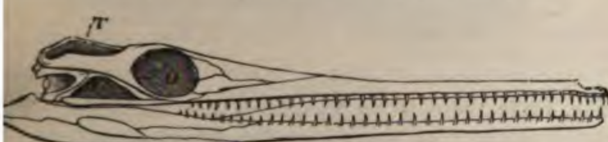
Family Teleosauridæ.—The members of this family are
distinguished from the more specialised forms by the circum
that the supratemporal fossæ are always much superior in
the orbits, and that the latter are completely separated by
bar from the infratemporal fossæ; both these features bein
shown in the accompanying figure of the cranium of *Steneo*
In front of the orbit there is always a well-marked vacuit

Fig. 1085.—Upper view of the cranium of *Steneosaurus Heberti*; from the Oxfor
France. Much reduced. The bones on the right side of the rostrum are imperfect,
should have been a line connecting the apex of the frontals with the suture dividing the
The large vacuities behind the orbits are the supratemporal fossæ, below which are
temporal fossæ.

shown in the figure); the dorsal scutes, when present, are ro
and arranged in two longitudinal rows; while the ventral bu
divided, and the component scutes of the posterior transvers
are united by suture. The axis vertebra carries two facets
rib, as in Dinosaurs. The members of this family were of
habits, and range throughout the Lias and Jurassic syst
Europe. They may be divided into two subfamilies.

In the subfamily *Teleosaurinæ* the skull is generally produc
a long slender rostrum, like that of the existing Gharial; the

ed by a long interval from the premaxillæ; the orbits are contour, and directed more or less completely frontally; nares look more or less anteriorly. The dermal armour veloped, and sclerotic plates were not present in the eye. genus *Teleosaurus* comprises small or medium-sized species, idily characterised by the teeth being inclined horizontally and extremely numerous. It is confined to the Lower and is abundant in the Stonesfield slate of Oxfordshire, nearly equivalent beds of Caen, in Normandy. The most t genus is, however, *Steneosaurus* (fig. 1085), in which *aurus* may be included, characterised by the elongated ie nearly vertical direction of the teeth, and the large size upratemporal fossæ, which in some species attain enormous ons. In the Liassic forms, separated generically by some is *Mystriosaurus*, the orbits are somewhat oblique, and the nporal fossæ are never excessively large; but in the numer- cies of the Lower and Middle (Oxford Clay) Jurassic the n of the orbits is entirely frontal, and the supratemporal e very large. In the figured *S. Heberti*, of the Lower part Oxford Clay, the skull is somewhat intermediate in these ; the orbits being slightly oblique, and the supratemporal rge. This genus does not appear to have survived above meridge Clay. In *Pelagosaurus* (fig. 1086) we have an



86.—Right lateral view of the skull of *Pelagosaurus typus*; from the Upper Lias of Normandy. Reduced. *T*, Supratemporal fossa; *O*, Orbit.

enus, represented only by two species of Liassic age; it is iished from the preceding by several characters; but more lly the form of the posterior nares, and the smaller and d supratemporal fossæ. The remains of the small *P. typus* ecially abundant in the Upper white Lias of Normandy, and rvellously perfect preservation of some of the skeletons has l the bony anatomy of this species to be as completely as in the case of an existing form. In *Machimosaurus*, of meridge Clay (Upper Jurassic) of both England and the ent, and *Teleidosaurus*, of the Fullers' Earth (Lower Jurassic) nandy, we have two genera in which the skull becomes much and broader, the teeth stouter and less numerous, and the nore oblique; and which thus connect the present with the next subfamily. *Machimosaurus*, which occurs both in Franc[e and] England, is the largest member of the order, the length [of] mandible exceeding 50 inches; the skull has been refer[red to] *Pliosaurus*. The teeth closely resemble those of *Goni[opholis]* having conical and deeply fluted crowns.

With the second subfamily, or *Metriorhynchinæ*, we come [to a] very remarkable group of Crocodiles, presenting certain speci[al] features unknown elsewhere in the entire order. The skull [(fig.] 1087) is either of moderate length or comparatively short; [the] nasals are either in contact with the premaxillæ, or separated [there]from by a short interval; the nares are directed frontally; the [orbits] are of very irregular contour, and placed completely on the sid[es of] the skull; and the teeth, which are never very numerous, [are] always of considerable size, and directed more or less [...]

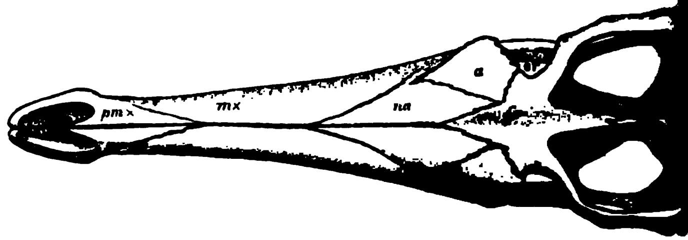


Fig. 1087.—The cranium of *Metriorhynchus hastifer*; from the Kimeridge Clay of Nor[mandy]. One-sixth natural size. *pmx*, Premaxilla; *mx*, Maxilla; *na*, Nasal; *a*, Prefrontal; *fr*, Fr[ontal]; *or*, Orbit. (After Deslongchamps.)

vertically, while there is no vacuity in the mandible. The mo[st] remarkable features of the group are, however, the developm[ent] of a ring of bony plates in the sclerotic of the eye, and [the] general or universal absence of a dermal armour. It is, inde[ed,] very curious to notice the correlation of these two features, si[nce] there is no known instance of the presence of both sclerotic pl[ates] and of dermal scutes in any reptile. The pelvis of this subfamily [is] also worthy of notice. Thus the ilia are very small subtriang[ular] bones articulating with long and downwardly curved sacral rib[s,] while the ischia are enormously large, with the shape of an isosce[les] triangle. This presents a remarkable contrast to *Steneosaurus*, whe[re] the sacral ribs are straight and directed outwards, while the ilium [is] larger, with a considerable portion projecting above the costal arti[c]ulation. In the genus *Metriorhynchus* the skull (fig. 1087) is [of] moderate length, and frequently somewhat slender, with the front[al] region slightly sculptured; there is a more or less well-marked p[re]maxillary expansion; the prefrontals (*a*) are very large, and ov[er]hang the orbits; while the teeth are curved and carinated, with t[...]

;enerally fluted at the base of the crown, but without ser-
n the carinæ. The pectoral limbs are extremely small.
ius ranges from the Oxford Clay to the Portland Oolite.
e Oxford Clay and Kelloway rock, both of the Continent
land, we meet with *M. superciliosus* and *M. moreli*, which
lily distinguished by the sculpturing of the frontals and
n and relations of the prefrontals. Beautiful examples
genus occur in the Oxford Clay near Peterborough, which
the absence of dermal scutes; a skull from this locality,
h the name *Steneosaurus dasycephalus* has been applied,
referred to *M. superciliosus*. The Portlandian form was de-
as *Steneosaurus gracilis*. It is probable that *Gnathosaurus*
achеosaurus are synonyms. The most specialised genus is
rus (*Cricosaurus* or *Dacosaurus*), in which the skull is com-
ly short, and is devoid of frontal sculpture, and also of the
illary expansion; while the teeth (fig. 1088) are compressed,
, and carinated, with distinct serrations on the carinæ. The
ecies, which occurs in the Lower Kimeridgian of Bavaria,

1088.—Crown of tooth of *Geosaurus maximus*; from the Kimeridge Clay of Ely. (After Wood-Mason.)

of comparatively small size, was long thought to belong
Mosasauridæ. A much larger form, occurring in the
dge, and perhaps the Oxford, Clay of England and the
onding beds of the Continent, has been described under
ne of *Dacosaurus*, but can be only specifically distinguished
e type. A tooth is shown in the accompanying woodcut.
ot improbable that vertebræ from the Lower Greensand of
y, described under the name of *Enaliosuchus*, indicate a
allied form.

embers of this family, of which the serial position is uncer-
y be mentioned small forms respectively from the Kimerid-
Bavaria and France, to which the names *Æolodon* and
æmus have been applied, both of which have a dermal
; the ventral shield consisting of a number of small and
oined scutes. In the type of *Æolodon* these scutes are only
pitted, and the teeth alternate in size.

LY GONIOPHOLIDIDÆ.—The members of this family resemble existing Crocodiles in having an open channel connecting the temporal fossa with the orbit. The orbits themselves are, over, usually but slightly smaller than the supratemporal fos only exceed them but little in size; while there is no pre vacuity. The dorsal scutes are rectangular, and may be ar either in two or in several longitudinal rows; while the v armour may form either a single or a double buckler, in whic posterior transverse rows of scutes may either imbricate or arti by suture. The members of this family inhabited freshwaters they range in time from the Purbeck (Upper Jurassic) to the den (Lower Cretaceous), and not improbably also to the U Greensand. Nearly all the known forms are European, but genus which may belong to this family is American; and the f is probably also represented in the Cretaceous of India. T subfamily divisions have been proposed, but before discussing we may allude to the genera *Suchosaurus* of the English We and *Hyposaurus* of the Cretaceous of North America and E which not improbably belong to this family, although their p affinities are not yet satisfactorily determined. The type of former genus is of very large size, and has the teeth greatly pressed; while in the latter the posterior teeth are of this type the anterior ones are rounded like those of *Goniopholis*, and symphysis of the mandible is elongated.

The first subfamily, or *Petrosuchinæ*, is very imperfectly kn and is represented only by the genus *Petrosuchus*, of the En Purbeck beds, in which the posterior nares are placed near middle of the skull, as in many of the *Teleosauridæ*, and the o are considerably smaller than the supratemporal fossæ. cranium itself is of moderate length.

The members of the second subfamily, or *Goniopholidinæ*, the posterior nares placed more posteriorly than in the prece group; while there are two longitudinal rows of dorsal scutes; the ventral buckler is divided, with the transverse rows of scut the posterior portion articulating by suture. In the first, or Lo rostrine, section of this subfamily the skull is elongated like th the existing Gharial; the nasals do not reach the nares, the sple bone enters into the mandibular symphysis, and the teeth numerous, and all nearly similar in size. It is represented onl *Pholidosaurus* (*Macrorhynchus*) of the German and English W den. In the Brevirostrine section, on the other hand, the sku short, like that of the true Crocodiles, the nasals sometimes re the nares, the splenial enters but very slightly into the symphys the mandible, and some of the teeth are much larger than others. The dorsal scutes present the peculiarity of articul with one another by means of a peg at one angle which fits in ket in the adjacent scute; an arrangement very similar to that aining in the scales of certain Ganoid fishes. The genus *Gonio-lis* is very characteristic of the Wealden and Purbeck, and has a nium of moderate length, with the nasals not reaching the nares, d the orbits rather smaller than the supratemporal fossæ. The e species attained very large dimensions, and was long since de known to the world by the late Dr Mantell, under the name the Swanage Crocodile; its blunt and grooved teeth, and charac-istic scutes, being comparatively common in the Wealden stone arries of Sussex. This genus has been recently recorded from e Jurassic of North America, where it had been previously de-ibed as *Amphicotylus*. Allied but considerably smaller forms m the Dorsetshire Purbeck constitute the genera *Nannosuchus* d *Oweniasuchus* (*Brachydectes*). The most specialised genus, wever, appears to be the minute *Theriosuchus* of the Purbeck, ich, in having the orbits slightly larger than the supratemporal sæ, approximates to the next subfamily, although retaining the gged dorsal scutes of *Goniopholis*. The nasals in this genus reach d partly divide the nares, as in the true Crocodiles; and we thus ve a comparatively close approximation to existing forms, which rendered still more manifest by the members of the next group.

In the genus *Bernissartia*, of the Belgian Wealden, which forms e type of the subfamily *Bernissartiinæ*, the skull is comparatively ort and broad, and has the posterior nares placed very close to e occipital condyle; while the orbits are decidedly larger than the pratemporal fossæ. Like existing Crocodiles, these reptiles were ovided with more than two longitudinal rows of dorsal scutes hich have no peg-and-socket); while their ventral buckler is un-vided, and has the transverse rows of scutes imbricating throughout. he resemblance to existing forms being completed by the pectoral mbs being considerably shorter than the pelvic pair. The verte-æ, however, still retained the primitive amphicœlous character. seems probable, from the position of the posterior nares, that the perfectly known genus *Hylæochampsa*, from the English Wealden, a closely allied form of rather larger dimensions; and it is not likely that certain procœlous vertebræ from the same formation hich have been described under the name of *Heterosuchus* may be-ng to this form; while others from the Cambridge Greensand and e Greensand of Austria, which have been referred to *Crocodilus*, ay also indicate allied reptiles, although there is a possibility that e owners of these vertebræ belonged to the next series. It will us be seen that if *Hylæochampsa*, or an allied form, had such pro-lous vertebræ, it would only require the development of palatal ates to the pterygoids to convert it into a Crocodilian of the odern type; and it is highly probable that such a form once existed, since it is most unlikely that the change from amphicœl to procœlous vertebræ took place precisely at the same time as pterygoids developed palatal plates. On the other hand there is equal *primâ facie* probability that these two changes may h occurred in the reverse order to that indicated above.

B. Procœlian Series.—In this series the vertebræ, with exception of five, are procœlous; the pterygoids develop pal plates to prolong the narial passage (fig. 1089); and all eustachian canals are enclosed bone. The dorsal scutes are, mo over, always arranged in more th two longitudinal rows; and wh there is a ventral buckler it is divided, and invariably consists more than eight rows of imbricat scutes, in which each scute is c posed of two separate pieces of bo The axis vertebra differs from that the *Teleosauridæ*, in having no c articulations; its rib having b shifted forward on to the centrum the atlas, or odontoid process.

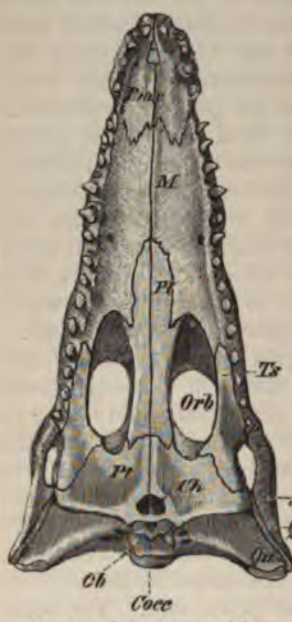


Fig. 1089.—Palatal aspect of the cranium of *Crocodilus*. Reduced. *Pmx*, Premaxilla; *M*, maxilla; *Pl*, Palatine; *Ts*, Transverse; *Pt*, Pterygoid; *Jg*, Jugal; *Qj*, Quadratojugal; *Qu*, Quadrate; *Ob*, Basioccipital; *Cocc*, Occipital condyle; *Orb*, Orbit; *Ch*, Posterior nares.

Family Crocodilidæ.—All sufficiently known members of series may be included in a si family, which agrees with the *Go pholididæ* in the free communicat of the infratemporal fossa with orbit, which is considerably la than the supratemporal fossæ. T family is first definitely known fr the Upper Cretaceous, and con ues to the present day, being rep sented in the freshwaters of m of the warmer regions of the glo If, however, the procœlous verte mentioned in the last series from the Greensand and Weal really indicate members of the present family, it will date from latter horizon. The form of the skull affords grounds for two tional divisions.

The Longirostrine section is represented at the present day o by the true Gharial (*Garialis*) of the Ganges, and Schlegel's Gha of Borneo. The skull is produced into a long narrow rostrum (1091), with the dental borders nearly straight; the nasals ne extend to the anterior nares, and are frequently separated from maxillæ; the supratemporal fossæ are of somewhat large size, sometimes exceed the orbits in this respect; while the mandi-ar symphysis is very long, and embraces the anterior portion of splenial bone. The teeth are always numerous, and are only ntly unequal in size; and neither of the existing species is pro-d with a ventral armour. In this group *Rhamphosuchus*, of the cene of the Siwalik Hills of India, was a gigantic form probably ween fifty and sixty feet in length, and characterised by the stout-s of the teeth, of which the upper series bites on the outer side he lower, as in the Alligators, instead of interlocking with them n other members of this group. In *Thoracosaurus*, again, of Cretaceous of North America, we have a genus remarkable for ining the preorbital vacuity of the *Teleosauridæ*, and in having supratemporal fossa larger than the orbit; these features apparently pointing to the ct descent of this genus from the last-named ily, without having passed through the inter-iate stage of the *Goniopholididæ*. The exist-Indian *Garialis gangeticus*, of which the den-succession is shown in fig. 1090, is one of the ting species of Reptiles of which remains are nd in the Pliocene of the Siwalik Hills. The e deposits have also yielded two more or less rly allied extinct species; while in the some-t older beds of Sind there occur two other cies differing considerably in the form of the t and other cranial characters from the existing esentative of the genus. One of these extinct cies (*G. pachyrhynchus*) appears to have attained ensions fully equal to those of *Rhamphosuchus*. other Gharialoid provisionally referred to the ent genus occurs in the Middle Eocene of cklesham, in Sussex; while species from the taceous of North America, which have been cribed under the generic name of *Holops*, may ve to be allied either to the present or to the t genus. In *Tomistoma*, typically represented he existing *T. Schlegeli* of Borneo, may be in-ded the fossil forms described under the names *Melitosaurus* and *Garialosuchus* (fig. 1091). This genus is ily distinguished from *Garialis* by the circumstance that the ls extend forwards to articulate with the premaxillæ (fig. 1091), ad of being separated from them by a long interval. A large l form (*Melitosaurus*) occurs in the Miocene of Malta, and a ler (*Garialosuchus*) in that of Austria. Another Gharialoid,

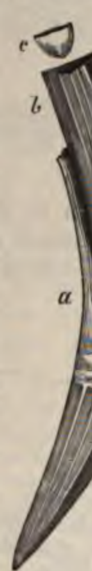


Fig. 1090.—Teeth of *Garialis gangeticus*, showing succession of germs (*b*, *c*) beneath the tooth in use (*a*). (After Owen.)

from the Upper Cretaceous of France and Maastricht, originally de-scribed as *Garialis macrorhynchus*, has also been provisionally in-cluded in the same genus. This form is, however, referred

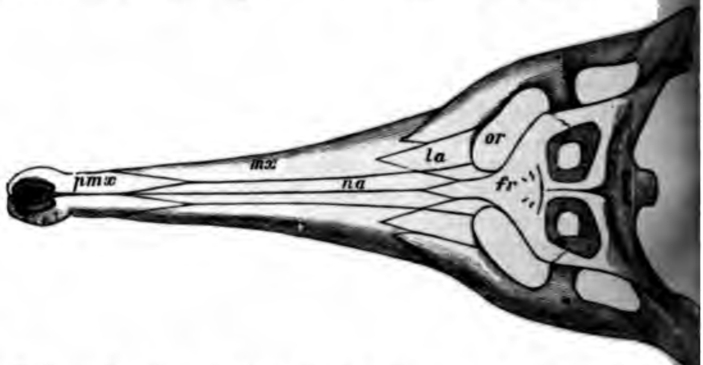


Fig. 1091.—Frontal aspect of the cranium of *Tomistoma eggenburgense*; from the Mioc Austria. One-tenth natural size. *pmx*, Premaxilla; *mx*, Maxilla; *na*, Nasal; *la*, Lachr *fr*, Frontal; *or*, Orbit. The vacuity behind the orbit is the infratemporal fossa. (After To and Kail.)

Dr Koken to *Thoracosaurus*, although it has no preorbital vacuit and the nasals reach the premaxillæ. It appears to connect th typical *Thoracosaurus* with the existing *Tomistoma*. Finally, th

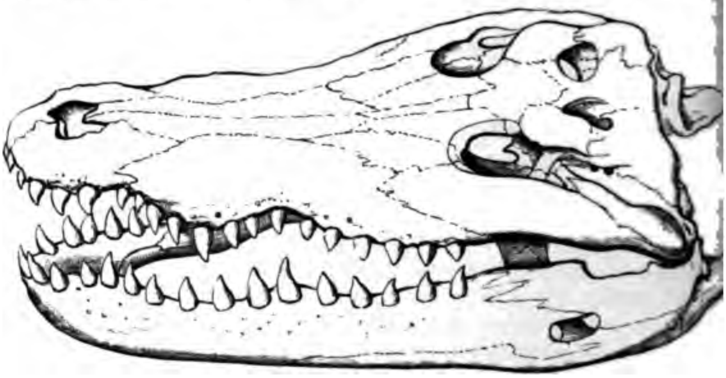


Fig. 1092.—Oblique left lateral and superior view of skull of *Crocodilus palustris*: In Much reduced. The two small vacuities to the right are the supratemporal fossæ; those advance are the orbits, while the single vacuity to the left is the nares; the bones in advanc the latter are the premaxillæ, and those behind the nasals.

imperfectly known *Thecachampsa*, from the Miocene of No America, should probably be placed in the present group.

The second, or Brevirostrine section, includes the true Crocodi and Alligators, and is characterised by having the skull short, ately elongated, with its dental borders thrown into distinct ns (fig. 1092); by the nasals always reaching the premaxillæ, equently extending down to the anterior nares (as in fig. 1092); so by the orbits being always larger than the supratemporal . The short symphysis of the mandible, from which the l element is entirely excluded (fig. 1093), is another striking . The teeth, moreover, vary in size in different parts of the and usually the third and ninth in the upper, and the fourth, equently also the first and eleventh, in the lower jaw (fig.

—Inner view of the left ramus of the mandible of a Crocodile. Reduced. *an*, Angular; Articular; *co*, Coronoid; *d*, Dentary; *s*, splenial; *su*, Surangular; *sy*, Symphysis.

are considerably larger than any of the rest. In the type *Crocodilus* the upper and lower teeth mutually interlock; the wer tooth bites into a perforation or a pit in the cranium, e fourth into a lateral notch; while the third lower tooth is There is, moreover, no ventral armour. This genus is now uted over nearly all the warmer regions of the globe, and it s to have had an equally extensive distribution in Tertiary

earliest representative of this genus seems to be *C. Spenceri*, of wer Eocene of both England and Italy, which was a species with aratively long muzzle like that of the living American *C. interme-* The genus is also represented in the Middle Tertiaries of Europe orth America. In the Pleistocene of Queensland we meet with s of the existing *C. porosus* (fig. 1079), which now ranges from lia to Eastern India; while in the Pliocene of the Siwalik Hills of here occur species closely allied to the short-snouted *C. palustris* 92) of that country, which makes the nearest approach in cranial ters to the Alligators and their allies.

locynodon is an extinct genus found in the Tertiaries of both e and North America, which presents characters intermediate n *Crocodilus* and *Alligator*. Thus the cranium (fig. 1094) is ort and broad; the upper teeth bite on the outer side of the the fourth lower tooth is normally received into a notch ccasionally into a pit) in the cranium; the third lower tooth rge as the fourth; and there is a complete ventral armour. ope this genus ranges from the Upper Eocene to the Lower ne (Upper Oligocene), and is common in the Tertiaries of the south of England, and also in those of France and Germany; some of the species from the latter deposits having been described as *Alligator*. The genus has also been recorded from the Upper Eocene of North America. The last, and in respect of cranial characters the most specialised, group of Crocodiles is now divided into the two genera *Caiman* and *Alligator*. In these forms both the first and the fourth lower tooth are received into pits in the upper jaw, so as to be concealed when the mouth is closed; the upper teeth bite on the outer side of the lower ones; the supratemporal fossæ are very small, and are occasionally obliterated; and the third lower tooth is smaller than the fourth. *Caiman* is distinguished by the presence of a ventral armour, and also by the circumstance that the nasals do not extend across the nares; and

Fig. 1094.—Oblique left lateral and palatal view of the facial part of the cranium of *Diplocynodon hantoniensis*; from the Upper Eocene of Hampshire. Reduced.

is now confined to Central and South America. In *Alligator*, on the other hand, which occurs at the present day in North America and China, the ventral armour is absent or extremely thin, and the nasals extend forwards so as to divide the narial aperture. Remains which are probably referable to *Caiman* occur in the Pleistocene cave-deposits of Brazil; but it does not appear that there is any certain evidence of fossil species of *Alligator*; the European, and probably some of the North American forms which have been referred to that genus, belonging to *Diplocynodon*. Finally, the name *Isselosaurus* has been recently applied to Crocodilian remains from the Middle Eocene of France which may really belong to one of the above-mentioned genera.

ORDER X. ORNITHOSAURIA.—The Pterodactyles, as the members of this extinct order are commonly termed, are among the most remarkable and strange Reptilian forms that Palæontology h

[1] According to the arrangement adopted by Mr Boulenger in his Brit Museum Catalogue of this order.

ealed to us. So strange, indeed, are they that some autho- have considered that the osaurs are entitled to rank istinct class; but they are ally Reptiles, and agree in ntrinsic characters with the two orders placed in the now under consideration. eir organisation is, however, ed for the purpose of flight h the air. Thus the body ipported during flight by a ranous expansion, or *pata-* which was mainly borne by eatly elongated phalangeals ulnar, or outermost digit of inus (fig. 1095, marked iv); iich also extended along the of the body to embrace the imbs and tail (fig. 1098). ertebræ are procœlous, and their neuro-central suture ated; the precaudal series numerous; the cervicals are than the dorsals; and from to six vertebræ are anchy- together to form the sacrum. ervical ribs in those cases they have been observed the Crocodilian type. The (figs. 1096, 1097) is rela- large; and although more s bird-like in general con- yet maintains the reptilian y the presence of the supra- ral fossæ, bounded by the on of the postorbital with the osal bone. Bird-like resem- s are, however, shown by cumstance that the bones of cull anchylosed together at rly age; and that the two of the mandible were com- welded together at their symphysis. Moreover, as in Birds, eater portion of the upper jaws is formed by the premaxillæ;

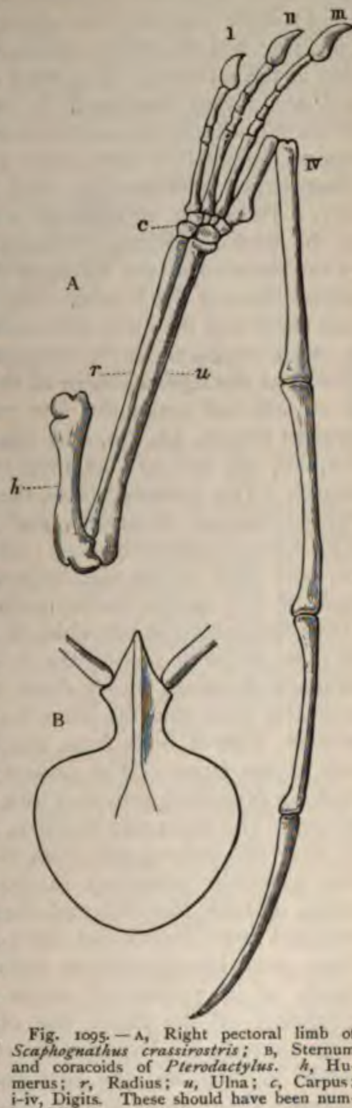


Fig. 1095.—A, Right pectoral limb of *Scaphognathus crassirostris*; B, Sternum and coracoids of *Pterodactylus*. *h*, Humerus; *r*, Radius; *u*, Ulna; *c*, Carpus; i–iv, Digits. These should have been numbered ii–v.

:he nares are similarly approximated to the orbits, with th
/ention of a preorbital vacuity, which (fig. 1096) may b
large; while the occipital condyle is situated on the base
:ranium; and the orbits are large, and there is generally an
:ing in the sclerotic. The teeth are invariably simple and p
and are always implanted in separate sockets. In the p
girdle the scapula and coracoid are long and bird-like, and th
has no fontanelle; there were no clavicles; but there was a
heart-shaped sternum (fig. 1095, B), carrying a median keel
orly. The angle of junction of the scapula and coracoid,
as the keeled sternum, curiously resemble the correspondin
in the skeleton of the Carinate Birds, and are consequently
unlike those of the Ratitæ. The carpus consists of two main
one distal and the other proximal;[1] while on its radial side
a small styliform ossification, regarded by Professors Ow
Marsh as the representative of the pollex—an identification
if correct, will make the four remaining digits which are
present the 2d, 3d, 4th, and 5th of the typical series, and
1st, 2d, 3d, and 4th as they are regarded by some write
1095). The phalangeals of the ulnar digit, as already mer
are enormously elongated, and the terminal joint has n
The pelvis is relatively weak; and although the ilium is e
on both sides of the acetabulum, the structure of both this
and of the pelvic limbs is far removed from the avia
Thus the pubis (or prepubis) is directed forwards, and the
is short and wide; while the pelvic limbs are relatively shor
fibula is, however, always fused with the tibia; and the as
may also unite with the latter bone; although the metatarsals
remain distinct both from one another, and also from th
row of the tarsus. The greater number of the bones are
and are frequently provided with pneumatic foramina, like t
Birds. The brain was bird-like, and the body was probably
In time this order ranges from the Lias to the Upper Chal
was especially abundant in the Upper Jurassic and Cre
strata of both the Old and New Worlds. Although the s
presents many remarkable resemblances to the Carinate Bi
these must be regarded as mainly due to adaptation for a
mode of life; since it seems clear that the Pterodacty
altogether off the direct line of the Avian pedigree.

SUBORDER I. PTERANODONTIA. — In this suborder te
totally wanting, and the jaws were probably completely ensl
in horn, like those of Birds. The skull (fig. 1096) has an en
supraoccipital crest, projecting far behind the occiput; and tl

[1] The carpus is erroneous in fig. 1095.

ompletely confluent with the preorbital vacuities. According fessor Marsh, these reptiles were mostly of gigantic size; some a spread of wing of nearly or quite 25 feet. And in order the powerful patagium in flight, the pectoral girdle was lly strengthened by the anchylosis of several vertebræ, and robust scapulæ articulating to the spines of these anchylosed

96.—Left lateral view of the skull of *Pteranodon longiceps*; from the Cretaceous of merica. One-twelfth natural size. *a*, Nares and preorbital vacuity; *b*, Orbit; *c*, ital crest; *d*, Angle of mandible; *q*, Quadrate; *s*, Symphysis (After Marsh.)

æ; this peculiar feature being virtually a repetition of the girdle and sacrum on a much larger scale.

ILY PTERANODONTIDÆ.—The type genus *Pteranodon* (fig. occurs in the Cretaceous of North America; and although nbers are generally of large size, it is also represented by one pecies—*P. nanus*. The coracoid and scapula were united, e oral aspects of the jaws have not the ridge and groove in *Ornithochirus*. *Ornithostoma*, of the Cambridge Green- nay have been an allied form. In *Nyctodactylus*, of the North an Cretaceous, Professor Marsh thinks that none of the vertebræ were anchylosed; and on this account the genus perhaps form the type of a distinct family.

ORDER 2. PTEROSAURIA.—In this, the typical, suborder teeth sent in both jaws; the cranium (fig. 1097) has no long supra- al crest directed backwards, and generally has the nares more completely separated from the preorbital vacuities. The is (at least usually) not anchylosed to the neural spines of rsal vertebræ, which are distinct from one another. This sub- s mainly European.

ILY PTERODACTYLIDÆ. — In the typical family the tail is fig. 1097); the jaws are toothed to their extremities; and gth of the metacarpus considerably exceeds half that of the g. 1097). The skull, which is extremely bird-like, may be ong or short, and has the nares imperfectly separated from orbital vacuities; while in the pelvic limb the astragalus is distinct from the tibia. In Europe this family is especially eristic of the Upper Jurassic, and is abundantly represented Lower Kimeridgian lithographic limestones of Bavaria, which,

from their fine structure, have preserved not only the smallest l
but not unfrequently also the impression of the membranou
gium. All the forms which can be certainly referred to this
are of small or moderate size. In *Ptenodraco*, of the lithog
limestones, we have a small Pterodactyle not larger than a sp
with a skull of very much the same contour as that of the lat

Fig. 1097.—Nearly entire skeleton of *Pterodactylus spectabilis*; from the Kimer
Bavaria. The ventral aspect is shown; and on the right side the ilium, and on the left
(*a*) is exposed.

which the teeth are confined to the extremities of the jaws, a
nares do not appear to be separated from the preorbital va
Pterodactylus itself (of which *Ornithocephalus*[1] and *Diopec*

[1] It has been proposed to take the name *Ornithocephalus* in place c
draco, a suggestion which is entirely opposed to all the rules of nome
The first use of the former name in this sense was made by Fit
1826.

are synonyms), on the other hand, has the skull produced into a long beak or rostrum (fig. 1097), in which the teeth extend over a considerable space, and the large nares are slightly separated from the preorbital vacuities. The scapula is not anchylosed to the coracoid; and the pubes are short and rounded (fig. 1097). This genus appears to be confined to the lithographic limestones; the typical *P. antiquus* being about the dimensions of a woodcock.

Apparently allied to this genus is *Dermodactylus*, of the Jurassic of North America, in which the bones are said to have thicker walls. The type species is estimated to have had a spread of wing of from five to six feet. Finally, in *Cycnorhamphus*, of the Solenhofen limestones, we have a genus with a broad expanded beak, like that of a Swan, with the teeth confined to the anterior extremity. This genus is represented by a single species of comparatively large size, known as *C. suevicus*.

Here we may conveniently notice some gigantic Pterodactyles from the Cretaceous system of Europe, of which, owing to the exceedingly imperfect remains hitherto discovered, the family position must be left undetermined. Remains of some of those forms were originally regarded as belonging to Birds, and described under the names of *Palæornis* (Wealden) and *Cimoliornis* (Chalk). All these forms may be provisionally included under the generic name of *Ornithochirus*, although it is highly probable that some of them may really be distinct; and there does not at present appear any very good reasons for separating a Purbeck form for which the name *Doratorhynchus* has been proposed. Many of these Pterodactyles were of gigantic size; the spread of wing of some of the larger species being estimated at as much as 25 feet. Probably the tail was long; the jaws were toothed to their extremities, and frequently the upper anterior teeth curved forwards to project in advance of the muzzle. The oral surfaces of the upper and lower jaws were marked by a longitudinal ridge and groove; the skull was either short and stout, or much elongated; the scapula was often anchylosed to the coracoid; and in some instances the astragalus united with the tibia. It has also been suggested that *Ornithochirus* had but three digits in the manus, but this statement requires confirmation. The name *Cretornis* has been applied to the remains of *Ornithochirus* from the Chalk of Bohemia.

FAMILY RHAMPHORHYNCHIDÆ.—In this family the tail was at least usually long (as in fig. 1098); the extremities of the jaws were in many instances edentulous; and the length of the metacarpus was much less than half that of the ulna (fig. 1095). The skull (fig. 1099) was less bird-like than in the type family, with the nares separated by a distinct bar from the preorbital vacuity, and was often comparatively short and stout; while in some instances the astragalus united with the tibia. This family certainly ranged from the Lias to the Upper Jurassic, but if *Ornithochirus* belong to it, its range must be extended to include the Cretaceous. In the genus *Scaphognathus* (fig. 1099) the teeth extend to the extremities of the jaws of the massive skull, in which the nares are separated by a broad bar from the larger preorbital vacuities. The tail of the type species is unknown, and in Goldfuss' restoration (fig. 1099) it was made like that of *Pterodactylus;* but Professor Zittel considers that it was elongated like that of *Rhamphorhynchus* and *Dimorphodon* (fig. 1101). The type species, which attains considerable dimensions, occurs in the Kimeridgian limestones of

Fig. 1098.—Restoration of *Dimorphodon macronyx*. Reduced. (After Owen.)

Bavaria, but the genus is also represented in the Upper Lias of Whitby. It is noteworthy that the peculiar form and relations of the jugal and quadratojugal found in the Dinosaurian genus *Diplodocus* (fig. 1076) also obtain in *Scaphognathus*. In *Rhamphorhynchus*, of the Kimeridgian of Bavaria, the extremities of the jaws are usually devoid of teeth; while in the hinder region the teeth incline forwards instead of having the nearly vertical direction of those of *Scaphognathus*. The scapula and coracoid were sometimes anchylosed; the astragalus was generally distinct from the tibia; the pes had either four or five digits; the pubes were slender, bent, and joined by a bony symphysis; while the long tail was strengthened by the ossification of its tendons. The membranous patagium developed a leaf-like expansion at the extremity of the tail, s beautifully shown in a specimen of the typical *R. Muensteri*, which a restoration is shown in the accompanying woodcut.

1099.—The skeleton and patagium of *Scaphognathus crassirostris* according to the ation of Goldfuss; from the Kimeridgian of Bavaria. Reduced. The presence of the first in the manus is incorrect; the tail should be long; while the patagium should have been extended posteriorly, as in fig. 1098.

species was of comparatively small size; but *R. grandis*, in h the astragalus united with the tibia, attained considerably er dimensions. *Rhamphocephalus*, of the Lower Jurassic Stones-

ig. 1100.—Restoration of *Rhamphorhynchus Muensteri* (*phyllurus*); from the Lower Kimeridgian of Bavaria. One-seventh natural size. (After Marsh.)

slate, is distinguished from the preceding genus by the form he teeth, and the great interorbital constriction of the cran- *Dorygnathus*, from the Upper Lias of Germany, appears to

have been an allied genus. In the Lower Liassic genus *D*
odon (fig. 1101) the jaws are toothed to their anterior extr
and the hinder teeth of th
dible are much smaller than
in front. Both the nares ar
orbital vacuities are of en
size, and are separated by a
bar. The coracoid is ancl
to the scapula; and the ast
united to the tibia. *Dimor*
is thus the earliest known re
tative of the order; and tl
species attained considerable
sions. Its remains occur in the
shales of Lyme Regis in Dors
and were first brought to nc
1822 by the indefatigable Dear
land.

Fig. 1101. — Restored skeleton of *Dimorphodon macronyx*; from the Lower Lias. Reduced. *f*, Ulnar digit; *m*, Other digits; *p*, Metatarsus. (After Owen.)

ORDINAL POSITION UNCERT
Here may be noticed a genus o
the serial position must for the
remain undecided. It is kn
Ornithodesmus, and was founde
an imperfect sacrum from the
Wealden, which has been rega
Avian, although its right to
tion from the Ornithosauria
by no means certain. It n
observed that the so-called *C*
pterus, of the Upper Jurassi
stones of Bavaria, said to b
acterised by the presence of o
digits in the ulnar digit of the
and which has been regar
Avian, appears to have been
ed upon an imperfect specin
Rhamphorhynchus; and it m
be mentioned that the name
thopterus is preoccupied by th
dopterous genus *Ornithoptera*.
ally, it has been suggested
tooth from the Trias of It
scribed under the name of *Tribelesodon* may indicate an O
saurian at that early period, but the evidence in support
view is at present wholly insufficient.

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CHAPTER LVI.

CLASS AVES.

General Structure.

The fifth class of the Vertebrata is that of Aves, or Birds, as we have already mentioned under the description of th Reptilia, presents a number of characters in common w latter. Birds, indeed, as Professor Huxley remarks, are so similar to Reptiles in all the most essential features c organisation, that they may be said to be merely an ex modified and aberrant Reptilian type. Their differentiat however, so great as to indicate without doubt their right t a distinct class. It will be unnecessary to recapitulate th acters common to Birds and Reptiles—together constituti province Sauropsida—and we may accordingly proceed t the distinctive features of the former class. It may be wel ever, to observe before proceeding further that, according arrangement proposed by Professor A. Newton, Birds are into three primary divisions or orders, respectively kno Saururæ, Ratitæ, and Carinatæ; the fossil representatives of will be noticed in the next chapter.

In the first place, all Birds, so far as can be ascertaine provided with the peculiar epidermal covering known as f which are totally unknown among the Reptiles; while ossifi in the dermis are extremely rare, and never take the form o scutes. No Bird, again, has procœlous vertebræ; while in isting forms the centra of the cervicals have cylindroidal, shaped, articular surfaces, although these are amphicœlous in Mesozoic forms. In no cases are there sacral ribs for atta of the ilia in the proper sacral vertebræ. The sternum backwardly-produced median processes for the ribs; all of are attached superiorly to its lateral borders. If an inter ever exists, it is fused with the clavicles into a compoun termed the furcula (fig. 1106). No Bird has more than three digits in the manus; all of which may be furnished with claws. The three elements of the pelvis are nearly always anchylosed together in the adult (fig. 1102); the ilium being produced in advance of the acetabulum (of which the inner wall is unossified), and the ischium and pubis directed backwards, in a more or less parallel direction, and only very rarely meeting in a ventral symphysis. The proximal row of the tarsus is always united with the tibia to form a tibio-tarsus; while the distal row coalesces with the

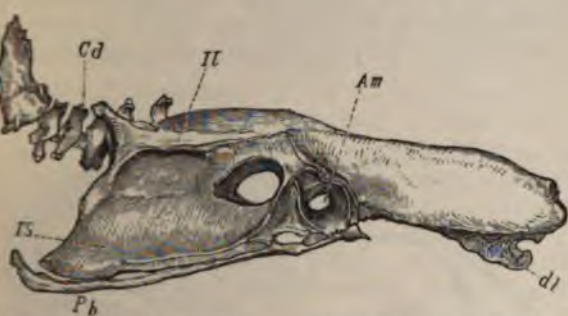

Fig. 1102.—Right lateral view of the pelvis and caudal vertebræ of a Fowl (*Gallus*). *Il*, Ilium; *Is*, Ischium; *Pb*, Pubis; *Am*, Acetabulum; *dl*, Dorso-lumbar vertebræ; *Cd*, Caudal do.

three median metatarsals to constitute a tarso-metatarsus. In all recent Birds only the right aortic arch is present; the arterial and venous circulations meeting only in the capillaries; and the blood is hot.

Some of the above characters are common to certain Reptiles; and it is only the whole of them collectively which can be regarded as characteristic of Birds as a class.

Noticing in rather more detail certain features of the osteology, it may be observed that the skeleton is usually remarkable for its combination of compactness and lightness, and also by the permeation of the greater number of the bones by air-cavities. The skull (fig. 1103) is formed on the general reptilian type, but is remarkable for the greater relative development of the brain-case, although this feature is nearly paralleled in the Ornithosauria. The component bones have a great tendency to unite in the adult by the obliteration of their sutures, and their texture is delicate and spongy, and totally unlike the ivory-like structure so generally observable among Reptiles. The single occipital condyle, which is mainly formed by the basioccipital, is not placed at the hinder extremity of the cranium, but becomes shifted forwards and downwards, so that the basal axis of the latter forms an angle with the axis of the vertebral column. In Reptiles a similar feature occurs in the Ornithosauria. The inferior temporal arcade, formed by the jugal and quadratojugal (fig. 1103), and connecting the maxilla with the quadrate, is invariably present, but the superior temporal arcade is always wanting; and there are never distinct postorbitals or postfrontals. The complete inclusion of the parietals in the roof of the brain-case prevents the formation of the posttemporal fossæ, which constitute such a characteristic feature in the skulls of the majority of Reptiles; and no Bird has a parietal foramen. The base of the cranium is formed by the basioccipital and basisphenoid, from the latter of which proceeds the rod-like sphenoidal rostrum, representing the anterior part of the parasphenoid; while the posterior portion

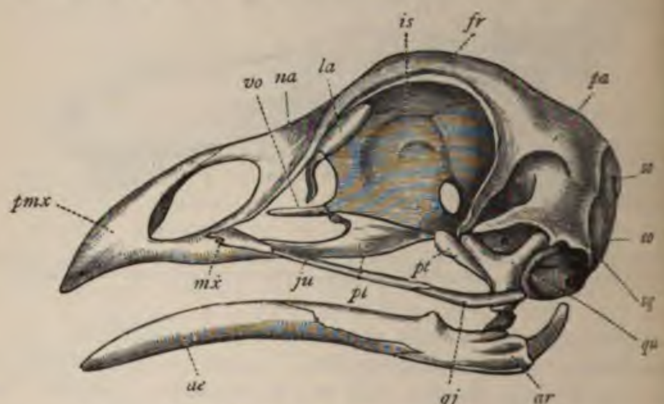

Fig. 1103.—Left lateral view of the skull of the Fowl. *de*, Dentary portion of the mandible; *ar*, Articular portion of do.; *qu*, Quadrate; *sq*, Squamosal; *eo*, Exoccipital; *so*, Supraoccipital; *pa*, Parietal; *fr*, Frontal; *la*, Lachrymal; *na*, Nasal; *vo*, Vomer; *pmx*, Premaxilla; *mx*, Maxilla; *ju*, Jugal; *qj*, Quadratojugal; *pt*, Pterygoid; *pl*, Palatine; *is*, Interorbital septum.

of the latter persists in the basitemporal plate underlying the basioccipital and basisphenoid. There is always a preorbital (lachrymonasal) vacuity between the nasal, lachrymal, and maxilla (the triangular space immediately behind the nasals in fig. 1103), as in many extinct Reptiles; and the interorbital septum is always more or less ossified. The narial aperture (fig. 1103) is lateral, and nearly always placed a short distance in advance of the orbit near the root of the beak. The greater portion of the latter is formed, as in the Ornithosauria, by the premaxillæ, which coalesce at a very early period in the middle line, and thus form a triradiate bone, giving off a median nasal and a pair of lateral maxillary processes. The pterygoids (fig. 1103) never unite together in the middle line to form a completely closed palate; and neither those bones nor the palatines ever develop inferior palatal plates to separate the narial sage from the mouth. In this respect, therefore, the develop-t of the Bird's skull does not attain such a specialisation as that the existing Crocodiles. The quadrate is usually movably at-hed to the squamosal; and the articulation of the palatopterygoid to the basipterygoid processes of the sphenoidal rostrum is also novable one, by which means the premaxillary beak can be moved a certain extent upon the rest of the skull. The vomers are bject to great variation. They underlie the ethmosphenoidal ion, and when present are connected posteriorly with the pala-es, except in the Ostrich. The relations of these and the other nes of the palate form important features in Professor Huxley's ssification of Birds; but since this is a subject to which the ention of the Palæontologist is but seldom directed, the reader sirous of further information must refer to other works. The gal and the quadratojugal are slender, rod-like bones, of which e former articulates with the equally slender maxilla, and the latter a hollow surface with the quadrate. In all existing Birds the ntary elements of the two rami of the mandible are always found lded at the symphysis into a single bone; but in the Cretaceous *hthyornis*, and perhaps in other Mesozoic forms, this union is nperfect. There is frequently a lateral vacuity between the den-ry and splenial, like that of the Crocodilia. The angle of the andible may be either truncated, or produced into a long recurved rocess, as in the Fowls (fig. 1103), Ducks, and Geese. In exist-ng and Tertiary Birds the beak is ensheathed in horn, and is totally devoid of teeth; but rudiments of teeth have been found in some Parrots. And in certain Mesozoic forms the premaxilla, maxilla, and dentary bones were furnished with a complete series of sharp teeth. A ring of bones is always developed in the sclerotic of the eye.

In some Mesozoic Birds the vertebral centra were amphicœlous, but in all others the vertebræ exhibit certain well-marked peculiari-ties. Thus the neural articulations are always well developed, and the arch is invariably articulated to the centrum. The neck is usually very long; the number of its vertebræ ranging from eight to twenty-three. The atlas vertebra forms a thin ring, in which the transverse ligament may be ossified; and the axis always has the odontoid process anchylosed to it. The succeeding cervicals have either short neural spines, or no spines at all; the anterior surfaces of their centra are cylindroidal and convex from above downwards, and concave from side to side, the reverse condition obtaining pos-teriorly (fig. 1104). These surfaces are usually described as saddle-shaped;[1] and there may be a hæmal spine inferiorly. In the imma-

[1] The term *heterocœlous* has been proposed for this type of vertebral structure.

ture Ratitæ the cervicals have ribs articulating with an upper and a lower process, as in the Crocodilia; and in the adult (fig. 1104) these ribs anchylose to the vertebræ, and thus resemble perforated transverse processes, in which the canal (*f*) serves for the protection of the vertebral artery.[1] In adult Carinatæ these lateral arches, as they may be termed, become further modified, and develop prolongations for the protection of other parts of the vasculo-neural system. The dorsal vertebræ are liable to variation in number; their centra usually resemble those of the cervical region, but in the Penguins the articular surfaces of some may be spheroidal an-

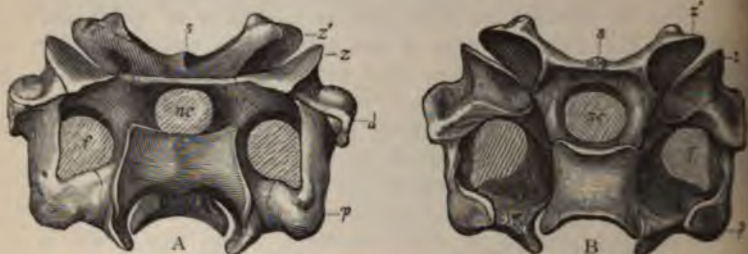

Fig. 1104.—(A) Anterior and (B) posterior views of a cervical vertebra of *Hesperornis regalis*; from the Cretaceous of North America. *s*, Neural spine; *z*, Prezygapophysis; *z'*, Postzygapophysis; *d*, Transverse process, or diapophysis; *p*, Rib-facet, or parapophysis; *nc*, Neural canal; *f*, Costal canal. (After Marsh.)

teriorly.[2] They usually have well-marked neural, and may or may not have inferior median spines; and they are in some instances anchylosed together, but in others are susceptible of a limited amount of motion. Throughout the whole dorsal series there is a well-developed transverse process from the arch for the tuberculum of the rib; while the centrum has a lateral facet for the capitulum. The method of costal articulation resembles, therefore, that obtaining in the first two dorsal vertebræ of the Crocodilia. These features are characteristic of all Birds. The dorsal vertebræ are succeeded posteriorly by a number of anchylosed vertebræ forming the sacrum. According, however, to the researches of Dr Gadow, only two or three of these vertebræ are truly sacral; those in front belonging to the lumbar, and those behind to the caudal region. Of the proper sacrals the two hindmost correspond to those of the Crocodilia, and the second of these to the single sacral of the Amphibia. The vertebræ articulating with the ilia do not develop ribs, but articulate

[1] This arrangement of the ribs is precisely similar to that occurring in certain Dinosaurs, as is shown in fig. 1071 (p. 1170).

[2] Certain Water and Wading Birds as well as Parrots, and the remarkable *Steatornis* have opisthocœlous dorsal vertebræ. The Parrots also have epiphyses to these vertebræ.

sverse processes placed on the arch. The anchylosed series als, which are sometimes termed *uro-sacral*, are in some in-, as in *Archæopteryx* and *Rhea*, followed by a considerable r of free vertebræ, but more usually by only a few, succeeded riangular terminal bone, known as the *pygostyle* (fig. 1106), carries the tail feathers and glands, and represents several ed vertebræ. In no known Birds are ossified intercentral its developed, with the exception of the inferior bar of the ertebra. Nearly all the dorsal ribs p tubercular and capitular pro-, and some have also uncinate pro- (fig. 1106, *up*). The sternum has of grooves superiorly for the re-n of the coracoids; and in the e (fig. 1105) it is rhomboidal and x, without trace of a median keel, evelopment taking place from two l centres. In the majority of Cari- the sternum (fig. 1106, *st*) is, how-, elongated, and has a strong median for the attachment of the pectoral cles. In this type two membranous

Fig. 1105.—Sternal region of the Ostrich (*Struthio*). Reduced. *s*, Scapula; *c*, Coracoid.

ities frequently exist in the posterior portion, which in the dry eton form holes or notches, separated by bony processes, which esent divisions of the Mammalian xiphisternum. In many inatæ, and especially the Passerines, there are also developed a lian manubrium sterni, and lateral costal processes for the attach-t of the ribs. The coracoid (fig. 1106, *c*) in the Carinatæ is an gated bone more like that of Crocodiles than that of Dinosaurs; s no fontanelle, and articulates at an acute angle with the scap- from which it usually remains distinct. It takes an equal share the latter in the formation of the glenoid cavity for the head of humerus, and at its distal end may overlap its fellow. In the itæ the coracoid (fig. 1111) is, however, generally shorter and e Dinosaurian-like, and may have a fontanelle, while its long is either coincident or parallel with that of the adjacent portion he scapula, with which it is invariably anchylosed in the adult. scapula in Carinate Birds (fig. 1106, *s*) consists of a thin and ow plate of bone, often extending backwards to a considerable th, and without any suprascapula. Occasionally an additional y rod is developed on the outer side of the scapula. The oidal ends of both the scapula and coracoid are divided into a oidal and a clavicular process in this order. In the same order clavicle is nearly always well developed, and fuses with its fellow orm the U-shaped furcula (fig. 1106, *fu*); but in the Ratitæ

ture Ratitæ the cervicals have ribs a
lower process, as in the Crocodilia
these ribs anchylose to the vertebræ
transverse processes, in which the ca
of the vertebral artery.[1] In adult
they may be termed, become fur
longations for the protection of
system. The dorsal vertebræ ar
their centra usually resemble th
the Penguins the articular surfac

Fig. 1104.—(A) Anterior and (B) posterio
from the Cretaceous of North America.
physis; *d*, Transverse process, or diapoph
f, Costal canal. (After Marsh.)

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well-developed transverse p
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Reduced. *pp*, Postorbital process; *ma*, Ma
up, Uncinate process; *co*, Pygostyle; *fu*,
Radius; *u*, Ulna; *ca*, Carpus; *mc*, Metacarp
Do. of second do.; *p*, Ilium; *f*, Femur; *pt*,
; *m*, First metatarsal; *pa*, Phalangeals.

ays separate ...
ing frequently ...
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nes of the carpus ...
the Jurassic *Archæopteryx* ...
: us the manus ...
ach the first ...
langeals: the terminal ...
law. In existing Carinate birds
are more or less completely fused
ofessor Weinsheimer, ten families
of phalangeals in the first digit as
bearing a claw: while four families
in the second digit, like *Archæopteryx*.
es is the terminal phalangeal provided
Carinates the third digit has only a
claw. Among the Ratitæ there are
Rhea; but *Apteryx* and *Casuarius* have
lawed. There is usually an interspace
d and third metacarpals which may be
bone.

elvis have been already briefly alluded to.
lways produced considerably on both sides
n some cases, as in the Apteryx, the anterior
at: it articulates with the long sacrum, of
as been already noticed. The ilium arches

over the greater part of the acetabulum, of which, as already me tioned, the centre is unossified, and has an external articular surfa for the great trochanter of the femur termed the *antitrochan* The ischium forms the hinder half of the inferior part of the ace bulum, and is a moderately broad bar of bone directed downwa and backwards, or occasionally backwards (fig. 1112). In t Carinatæ (fig. 1102) it generally unites inferiorly with the ilium, which means the upper part of the ilio-ischiatic notch is conver into a foramen; but in the Ratitæ (figs. 1107, 1112) there is such union. In *Rhea* alone, among existing Birds, the ischia un in a ventral symphysis. The pubis is generally a long and slen

Fig. 1107.—Left side of the pelvis of the Emeu (*Dromæus*). Reduced. *il*, Ilium; *is*, Ischia *p'*, Pubis; *p*, Pectineal process of do.; *a*, Acetabulum. (After Marsh.)

bone running parallel to the ischium, and entering into the anteri part of the lower border of the acetabulum; it frequently gives o a pectineal process (fig. 1107), which is apparently homologous wit the preacetabular process of the pubis of the Ornithopodous Dino sauria. The Ostrich (*Struthio*) is peculiar among living Birds i having a symphysis pubis; while in *Archæopteryx* alone are the thre pelvic bones separate. The femur is a short thick bone, with it head placed at right angles to the shaft, as in certain Dinosauria Its condyles are large, and antero-posteriorly elongated. A patell is frequently present, and may be double. The fibula is always im perfect distally, and may be completely anchylosed to the tibia The latter, or tibio-tarsus as it should be correctly termed, is a very characteristic bone; and is always longer than the femur. Proxi mally this bone is expanded and produced into an anterior cnemia process, like that of the Dinosauria, which may extend above th knee-joint; and the distal extremity (fig. 1108, A) has a trochlea like surface, and consists of the astragalus of the tarsus, which ha been completely fused with the tibia. On the anterior surface o bove the astragalus, there is frequently (as in fig. ›ny bridge over the channel for the extensor tendons of 'he tarso-metatarsus (fig. 1106, *tm*) immediately suc- bia; and consists proximally of the distal portion ;, with which the metatarsals of the are usually com- d to form a rod- enerally terminat- distal pulley-like the articulation of als. In the Pen- er, intervals exist three component e shaft; and in only two metatar- to the compound enerally the me- rsal at its distal t somewhat in ad- e other two (fig. The form of the les of this bone acteristic of differ- f Birds. In cases allux, or first digit, it is only the dis- of its metatarsus

Fig. 1108.—*Ibis melanocephala*. The distal portion of the right tibio-tarsus (A) and left tarso-metatarsus (B).

tached to the posterior aspect of the tarso-metatarsus. ird has any trace of a fifth digit, and the number of vary from two (Ostrich) to four (Parrots). In four-toed halangeals generally number 2, 3, 4, 5, reckoning from llux) to the fourth digit.

ase in an arithmetical ratio of the phalangeals of the toes, in rom the inner to the outer side of the foot, obtains in almost l enables us readily to detect which digit is suppressed, when our are not all present. Variations of different kinds exist, the number and disposition of the toes. In many Birds— 'arrots—the outermost toe is turned backwards, so that there in front and two behind; whilst in the Trogons the inner toe k with the hallux, and the outermost one is turned forwards. ain, the outer toe is normally directed forwards, but can be vards at the will of the animal. In the Swifts, on the other ur toes are present, but they are all turned forwards. In -especially amongst the Anserine birds—the hallux is wholly udimentary. In the Emeu, Cassowary, Bustards, and other allux is invariably absent, and the foot is three-toed. In the

Ostrich both the hallux and the second toe are wanting, and the foo sists simply of the third and fourth digits.

In regard to their geological distribution it should be obs that the remains of Birds are generally by no means so comm ossiferous deposits as those of Mammals. This scarcity is pro in part due to the comparatively small size and fragile nature bones of a large number of members of the class; and also, C. Lyell has observed, to the circumstance that "the pow flight possessed by most birds would ensure them against peri by numerous casualties to which quadrupeds are exposed d floods;" so that, "if they chance to be drowned, or to die swimming on water, it will scarcely ever happen that they w submerged so as to become preserved in sedimentary de since, from the lightness of the bones, the carcass would r long afloat, and would be liable to be devoured by predaceou mals." To these considerations must be added the absence of in the great majority of Birds, whereby we are deprived of evi which in the case of Mammals has thrown most important upon the nature and affinity of fossil forms.

The earliest suggestion of the occurrence of Birds is aff by impressions of huge Sauropsidan feet (fig. 1109) found i

Fig. 1109.—Sauropsidan footprint, and impressions of rain-drops; from the Trias of t Connecticut Valley. Reduced.

reputed Triassic sandstone of the Connecticut Valley in the U States. These impressions were evidently made either by Orn podous Dinosaurs, or by Ratite Birds; and the occurrence of tain reptilian bones in the same deposits indicates that at least s of them are probably of Dinosaurian origin. The absence of y a Reptile. Of the extremely generalised nature of ention is made in the next chapter. In the Cretaceous rth America we find not only the remarkable toothed were already differentiated into the Ratite and Carinate ; but there were apparently others more nearly allied pes. Bird-remains also occur rarely, and in a very tate, in the Upper Cretaceous of Europe. With the ter upon an Avian fauna of a decidedly modern type ; eriod of the Lower Miocene the greater number of rders were well represented.

present to a great extent in the dark as to the manner s branched off from the primitive Sauropsidan stock ; y evident that the Dinosauria are those Reptiles most to Birds, and that the Ornithosauria are totally out of cestral line,—the curious resemblance which they prete Birds being apparently solely due to their somewhat of life.

o the mode of origin of the Ratite and Carinate modificatructure, we may quote from an admirable article by Procon, who observes that—"First of all we find that while sessed the teeth they had inherited from their Reptilian remarkable and very distinct types of the class had already pearance, and we must note that these two types are those t the present day, and even now divide the class into the rinatæ. Furthermore, while the Ratite type (*Hesperornis*) ind of teeth, arrayed in grooves, which indicate (in Repa low morphological rank, the Carinate type (*Ichthyornis*) th teeth set in sockets and showing a higher development. hand, this early Carinate type has vertebræ, whose comple biconcave form is equally evidence of a rank unquesbut the saddle-shaped vertebræ of the contemporary Ratite testify to a more exalted position. Reference has been the jaw was still variable. There is no reason to think that at t any Reptile (with the exception of Pterodactyles, which, as h been said, are certainly not in the line of Birds' ancestors) ha sternum. Hence it seems almost impossible that the first B have had one; that is to say, it must have been practically of type. Professor Marsh has shown that there is good reason fo that the power of flight was gradually acquired by Birds, anc power would be associated the development of a keel to the st which the volant faculty so much depends. . . . Thus the Car would, from all we can see at present, appear to have been ev the Ratite." After observing that embryological and distribut afford support to this view, Professor Newton continues a "No doubt the difficulty presented by the biconcave vertebræ liest known representative of the Carinate type is a considerabl to the view just taken. But Professor Marsh has shown that i cervical vertebra of *Ichthyornis* 'we catch nature in the act of modifying one form of vertebra into another, for this singl in *Ichthyornis* is in vertical section 'moderately convex, while tr it is strongly concave, thus presenting a near approach to the s articulation;' and he proceeds to point out that this specialis occurs at the first bend of the neck, and, greatly facilitating m vertical plane, is 'mainly due originally to its predominance.' of the vertebræ would accordingly seem to be as much corre the mobility of the neck as is the form of the sternum with the flight. If, therefore, the development of the saddle shape be tion of development, as well may be the outgrowth of a keel." sion, the Professor observes that the question must be regard unsettled, although his own opinion is strongly in favour of being the earlier type.

On the other hand, Dr Gadow, in a communication of later cludes that the Ratitæ were most probably descendants of Bi formerly possessed the power of flight; this view being said ported by the structure of the wings, and the nature of the feath young.

In the following chapter a brief summary is given of divisions of Birds, with mention of those families known presented in a fossil state. It would, however, exceed the this work to give even the leading osteological characters families, since, owing to the great general similarity in the of all Carinate Birds, such characters could only be indicat introduction of a great mass of detail.

It should also be observed that the majority of writers three primary divisions of Birds as subclasses, and the divisions as orders, with the proviso that such orders ar different value from those of Reptiles. With the object of this inequality the view of Professor Huxley, who has te primary divisions orders and the secondary ones suborders, followed in this work.

CHAPTER LVII.

CLASS AVES.

ORDERS SAURURÆ, RATITÆ, AND CARINATÆ.

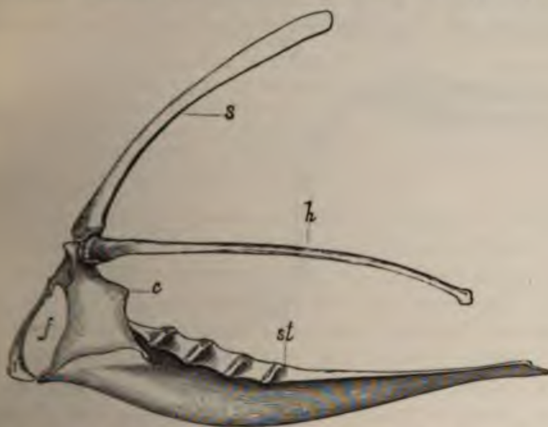
ER I. SAURURÆ.—This extinct order is represented only by *æopteryx*, and may be characterised by the metacarpals being ate, and by the tail being longer than the body, and not nating in a pygostyle.

MILY ARCHÆOPTERYGIDÆ.—*Archæopteryx*, including birds of t the size of the common Rook, is found in the lithographic tones of Solenhofen, near Pappenheim, in Bavaria, which are epresentatives of the lower part of the English Kimeridge Clay. genus was first made known by the impression of a single feather, hich the late Professor H. von Meyer gave the name *A. lithohica*. Subsequently the greater part of a skeleton, with imsions of the feathers of the wings and tail (fig. 1110), was ined, which Sir R. Owen named *A. macrura;* while recently cond skeleton has been found which some writers regard as cating a distinct species from the first. Of these two skeletons former is preserved in the British and the latter in the Berlin seum. Professor Carl Vogt, who first described the Berlin cimen, regarded *Archæopteryx* as a Reptile; but there can be hesitation in classing it among the Birds. The jaws were fured with teeth; the vertebræ were biconcave; and there was a l-ossified sternum, of considerable breadth, and probably pro-ed with a carina. In the manus the three metacarpals remained inct; and there were also three separate digits, each of which terminated by a claw. In the pelvis the three component nents exhibit the Reptilian character of remaining distinct ughout life; and it is thought probable that the ischia united ventral symphysis. The distal portion of the fibula is placed ront of the tibia; and the metatarsals were either separate or very imperfectly united together. The tail, again (fig. 1110), differs from that of all other known Birds in that it consists of a series of long vertebræ, gradually tapering to the extremity, and each of which carries a pair of feathers. From the absence of impressions of feathers in the region of the body, it has been thought that only the wings and tail had these appendages; but it is far more probable that the feathers had fallen from the body as it lay on the old sea-shore, while those of the wings and tail still

Fig. 1110.—Part of the skeleton, with impressions of the feathers of the wings and tail, of *Archæopteryx macrura*: from the lithographic limestone of Bavaria. Reduced.

adhered to their attachments. In the figure of the British Museum specimen of *A. macrura* (fig. 1110) the head is not shown; but it exists in an imperfect state of preservation in the slab. Till we know more of the other Birds of the Jurassic, the true relationship of *Archæopteryx* to existing forms cannot be determined.

ORDER II. RATITÆ.—The Ratitæ, or Struthious Birds, differ from the preceding order by the anchylosis of the metacarpals (when present) and the short tail, which may terminate in a pygostyle. They are further characterised by the sternum (figs. 1105, 1111) being devoid of a keel; by the long axes of the adjacent portions of the scapula and coracoid being approximately in the same line (fig. 1111), or at least forming an exceedingly obtuse angle at their junction; by the wings being useless for flight; and by the peculiar characters of the pelvis (figs. 1107, 1112), which have been already mentioned. There are, moreover ortant osteological characters connected with the palatal aspect he skull which cannot be noticed here; and some other features e been mentioned in the preceding chapter. The massive bones frequently filled with marrow. In all forms the fibula remains te distinct from the tibia; and the distal end of the latter fre-



ig. 1111.—Left half of the pectoral girdle and sternum of *Hesperornis regalis*; from the taceous of North America. Reduced. *s*, Scapula; *h*, Humerus; *c*, Coracoid; *f*, Clavicle; Sternum. (After Marsh.)

ently has no bridge over the extensor tendons. In all existing ms the plumage presents the remarkable peculiarity that the rbs of the feathers, instead of being connected with one another hooked barbules, as is usually the case, are remote and dis-nnected from one another, presenting some resemblance to irs.

This order embraces the largest known members of the whole

Fig. 1112.—Left half of the pelvis of *Hesperornis regalis*; from the Cretaceous of North America. Reduced. Letters as in fig. 1107. (After Marsh.)

ass; and from the scattered distribution of both its existing and ssil representatives is evidently an extremely ancient type. Its lations to the Carinatæ have been already alluded to in the pre-eding chapter. The order may be divided into two series, accord-ng to the presence or absence of teeth.

TOOTHED SERIES.—In this extinct series teeth are prese the jaws.

SUBORDER I. ODONTOLCÆ.—The type and only known r sentative of this suborder is *Hesperornis*, of the Cretaceous of N America. In this remarkable Bird (fig. 1113) the jaws (fig. 1 were provided with a series of sharp-pointed teeth, sunk in a continuous groove; but the anterior portion of the upper jaw

Fig. 1113.—Skeleton of *Hesperornis regalis*; from the Cretaceous of North America About one-tenth natural size. (After Marsh.)

edentulous, and probably sheathed in a horny covering like th existing Birds. Various parts of the skeleton are represente figs. 1111, 1112, and 1117.

In its whole skeletal organisation *Hesperornis* conforms strictly t existing Ratite type; but there were four digits in the pes (all of v were directed forwards), and Professor Marsh believes that it w aquatic habits, and compares it to a swimming Ostrich. Accord the description of the same authority, the tail consists of about t vertebræ, of which the last three or four are amalgamated to form terminal mass, there being at the same time clear indications that the tail was capable of an up and down movement in a vertical plane, thus probably fitting it to serve as a swimming-paddle or rudder. The vertebræ of the cervical and dorsal regions are of the ordinary ornithic type. The legs were powerfully constructed, and the feet were adapted to assist the bird in rapid motion through the water. The known remains of the typical *Hesperornis regalis* (fig. 1113) prove it to have been of larger dimensions than any of the aquatic members of the class with which we are acquainted at the present day. It appears to have stood between five and six feet high, and its inability to fly is fully compensated for by the numerous adaptations of its structure to a watery life. Its teeth prove it to have been carnivorous in its habits, and it probably lived upon fishes. A second species of this genus occurs in the same deposits, and is known as *Hesperornis crassipes;* but it was originally regarded as belonging to a distinct genus, and named *Lestornis.*

TOOTHLESS SERIES.—This series, which includes the whole of the remaining forms, is characterised by the absence of teeth.

SUBORDER 2. ÆPYORNITHES.—This suborder is represented by a single family, the *Æpyornithidæ*, of the Pleistocene of Madagascar. The one known genus, *Æpyornis*, is characterised by the shortness of the beak; the small wings; the absence of a tibial bridge over the extensor tendons; and the presence of a hallux in the pes. The typical *Æ. maximus* appears to have attained dimensions rivalling those of the largest species of *Dinornis* (to be shortly mentioned); and eggs have been found in association with the bones measuring fourteen inches in diameter, and computed to be equal in capacity to three eggs of the Ostrich. At least two smaller species of the same genus occur in the Madagascar Pleistocene.

SUBORDER 3. APTERYGES.—The members of the second suborder of this series are confined to New Zealand, and may all be included in the family *Apterygidæ*, which is now represented by the Kiwis or *Apteryx* (fig. 1114). They are distinguished from all other existing members of the order by their extremely long and slender beak, which is adapted for probing the soft marshy ground which they frequent in search of worms and other food. Omitting mention of the peculiar cranial and sacral characters, it may be observed that the wing has a comparatively short humerus, and not more than one ungual phalangeal. The tibia is furnished with a bony bridge over the extensor tendons; and there is a hallux to the pes. The feathers have no aftershafts. The Kiwis are essentially nocturnal in their habits. Remains of the existing species of *Apteryx* are found fossil in the Recent and Pleistocene deposits of New Zealand; while some much larger bones from the same deposits have been described by the late Sir Julius von Haast under the name of *Megalapteryx*, which appears to have been a giant form closely allied to the existing genus.

SUBORDER 4. IMMANES.—This recently extinct group, like t last, is almost peculiar to New Zealand, and comprises some of t largest known Birds. The beak (fig. 1115) is short; the wings either very small or totally wanting; the tibia has a distal brid over the extensor tendons; and in some instances there was hallux in the pes. The characters of the skull and pelvis co nearest to those of the next suborder, and the feathers have aft shafts. This group has been divided into the *Dinornithidæ* a *Palapterygidæ*, on account of the absence of the hallux in t former. Although this distinction has been doubted by so writers, who consider that *Dinornis* had a hallux, it appears to

Fig. 1114.—*Apteryx australis*, New Zealand.

a valid one. Apart, however, from this point, according to the Sir J. von Haast, the *Palapterygidæ* were provided with r mentary wings, while in the *Dinornithidæ* those appendages v totally absent. Mr De Vis has described some bird-bones fi the Pleistocene of Queensland under the name of *Dinornis que landiæ*; this being the only instance in which remains of this gr have been recorded elsewhere than in New Zealand. Sir J. Haast proposes to divide the *Palapterygidæ* into *Palapteryx* *Euryapteryx*, and the *Dinornithidæ* into *Dinornis* and *Mionorni*

The first evidence of the existence of this marvellous group was affor by a fragment of the shaft of one of the bones of the leg brought to chard Owen at a time when the existence of such huge Birds was ally unsuspected, and upon which evidence he founded the type mus. That the Moas, as these Birds are termed by the Maories of ew Zealand, have only been exterminated at a comparatively recent te is proved by the occurrence of nearly entire skeletons with the skin nd feathers still adhering to them, as well as by fragments of the eggs taining their original pale-green colour. The largest species is *D. ximus*, of which the total height was about ten feet, the tibia easuring a yard in length. Another species, *D. elephantopus* (fig.

Fig. 1115.—Skeleton of *Dinornis elephantopus*; from the Pleistocene of New Zealand. Greatly reduced. (After Owen.)

1115), although not standing more than about six feet in height, was of even more massive construction, the toe-bones almost rivalling those of the elephant in size. The number of species described is very large.

SUBORDER 5. MEGISTANES.—The Emeus and Cassowaries are characterised by certain structural peculiarities in the base of the short cranium; by the moderately long humerus; the presence of only one complete digit in the manus, which is furnished with a claw; the absence of a ventral symphysis in the pubes or ischia;

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t the majority should find a place
opteryx, of the Upper Jurassic of
already mentioned, to be consider-
Avian at all. In the Cretaceous of
patornis, *Graculavus*, *Laornis*, *Palæo-*
any or all of which probably belong to
gland the oldest known bird-remains
Greensand, and have been named *Ena-*
is probable that they may indicate more
of these vertebræ have more or less flat-
arso-metatarsus, in which the fusion of the
incomplete, is compared to that of the
to that of *Ichthyornis*, and it is high

the want of a bridge over the extensor tendons in the tibia the suppression of the hallux. The family *Dromæidæ* is sented by the existing Emeu (*Dromæus*) of Australia, and a fossil species in the Pleistocene of the same country. *Drom* from the latter deposits, is an extinct genus referable to this f The characters of the pelvis of the existing genus are shown 1107. The *Casuariidæ*, now characteristic of the Austra region, have not hitherto been definitely recorded in a fossil although it is possible that a phalangeal from the Indian Si may be referable to this family.

SUBORDER 6. RHEÆ.—The *Rheidæ*, which alone constitut group, and are confined to South America, differ from the stanes by the structure of the palate, as well as by the longe merus, the presence of three digits (of which two are clawed) i manus, by the ventral union of the ischia, and the absence aftershaft to the feathers. Remains of *Rhea*, which are refer the existing species, occur in the Pleistocene cave-deposits of]

SUBORDER 7. STRUTHIONES.—The family *Struthionidæ* i sole representative of this suborder; the only existing species the Ostrich (*Struthio camelus*), which is now confined to Afric Arabia, although it formerly ranged into Persia, and probabl to Baluchistan and the north-west frontier of India. In ad to the characters of the palate, *Struthio* differs from *Rhea* l union of the pubes in a ventral symphysis, and also by the su sion of the second digit of the pes, in consequence of whi distal end of the tarso-metatarsus has but two trochleæ. This is represented in the Pliocene Siwaliks of India, and also i Lower Pliocene of the Isle of Samos, in the Turkish archip by remains referred to two species. These forms, which m specifically the same, appear closely allied to the existing O An egg, from Tertiary beds near Gallipoli—the ancient Chers —described under the name of *Struthiolithus*, probably belo the existing genus, and very likely to the species occurring at S These fossil forms point to the conclusion that the original ho the genus was probably in Asia.

SUBORDER 8. GASTORNITHES. — The *Gastornithidæ*, who mains occur in the Lower Eocene of Europe, were large which may probably be classed with the Ratitæ, and are appa entitled to distinct subordinal rank. Their tibia agrees with tl the Apteryges and Immanes in having a bony bridge over tl tensor tendons, but makes a curious approximation in shape t of certain members of the Carinate suborder Anseres. The were somewhat larger than in the Ostrich; and the cranium, is estimated to have been fifteen inches in length, had the al margins of the jaws serrated, as in the genus *Odontoptery*

Remains of *Gastornis* have been recorded from Meudon, is, from Rheims, and from Croydon, and have been referred pecies. The huge *Diatryma*, from the Lower Eocene of merica, appears to be closely allied to, if not identical with, is. Bird-bones from the Tertiary of South America, de- by Dr Moreno under the name of *Mesembriornis*, and com- the Anseres, probably indicate a member of this group, ey are fully as large as the corresponding bones of the

also may be noticed an imperfect cranium from the London scribed by Sir R. Owen as *Dasornis*, and regarded by him ining to a Ratite Bird. And it may be also mentioned that rfect limb-bone from these deposits, which has been named *nis*, may perhaps belong to the same genus.

R III. CARINATÆ.—The third order, which is now by far t numerously represented, is generally characterised by the of a median keel to the sternum, and by the long axes of cent portions of the scapula and coracoid forming at their an acute or slightly obtuse angle, as well as by the upward n of the ischium towards the ilium (fig. 1102). In most e wings are adapted for flight, but in some instances they come atrophied, while in others they are modified into ng organs.

is still considerable diversity of views obtaining among logists as to the classification of this order, and all such must consequently be regarded as more or less provisional. resent work the classification adopted by Mr P. L. Sclater ed in the main, although certain modifications suggested by r Newton have been incorporated.

e noticing those fossil forms which are susceptible of being in definite groups it will be advisable to mention briefly remains of which the affinity has not yet been determined, it is probable that at least the majority should find a place present order. As to *Laopteryx*, of the Upper Jurassic of merica, there appears, as already mentioned, to be consider- ubt whether it is really Avian at all. In the Cretaceous of e country we have *Apatornis*, *Graculavus*, *Laornis*, *Palæo-* and *Telmatornis*; many or all of which probably belong to t suborder. In England the oldest known bird-remains the Cambridge Greensand, and have been named *Ena-* although it is quite probable that they may indicate more e genus. Some of these vertebræ have more or less flat- ntra; while the tarso-metatarsus, in which the fusion of the ent elements is incomplete, is compared to that of the exist- *mbus* and also to that of *Ichthyornis*, and it is highly prob-

able that these Birds were allied to the latter genus. The b
from the Cretaceous of Europe described as *Palæornis*, *Cimoli*
and *Cretornis*, belong to Ornithosauria.

In the Tertiary we have *Eupterornis* and *Remiornis* from
Lower Eocene of Rheims; while the Upper Eocene (Lower O

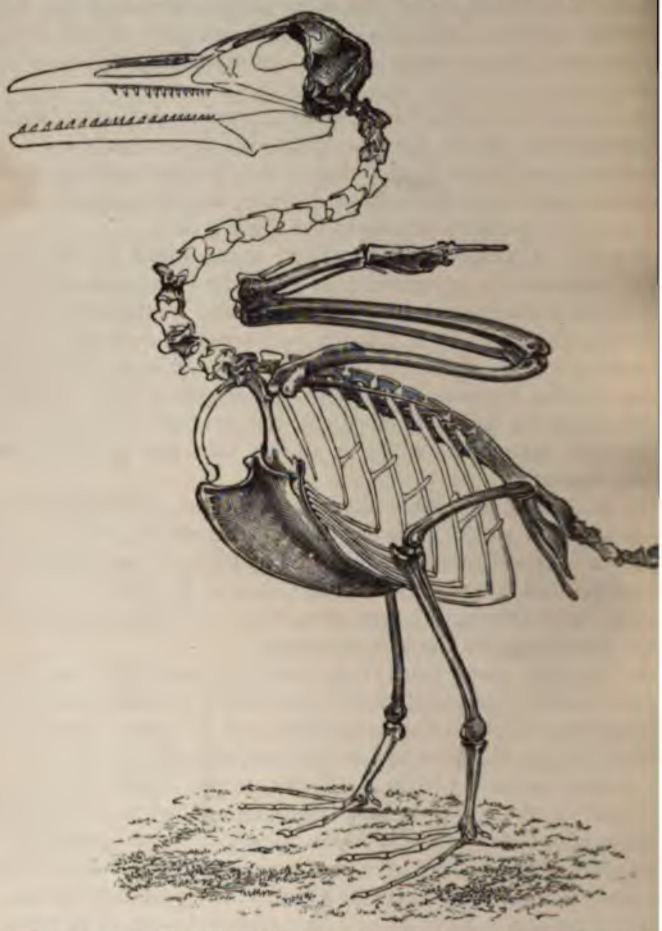
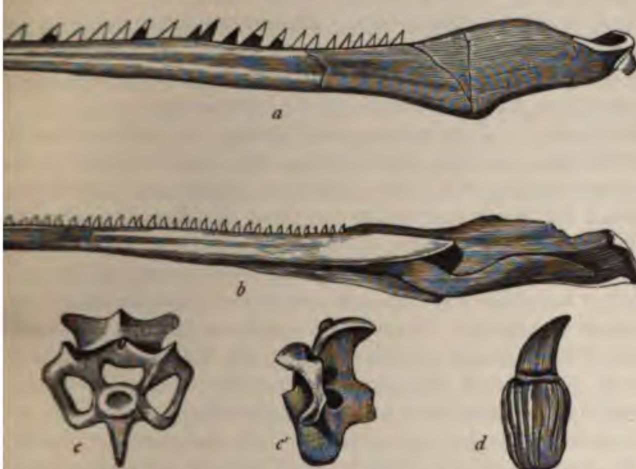


Fig. 1116.—Restoration of the skeleton of *Ichthyornis dispar*; from the Cretaceous
North America. Reduced. (After Marsh.)

cene) of Hampshire has yielded *Macrornis*, and the Lower Mi
(Upper Oligocene) of the same county *Ptenornis*.

TOOTHED SERIES.—This extinct series is characterised by
presence of teeth, and typically of amphicœlous vertebræ.

ORDER 1. ODONTORMÆ.—The one suborder which is the nown representative of this series contains the family *Ichthy-idæ*, from the North American Cretaceous, of which *Ichthy-*s the only definitely known genus, although it is highly prob-at *Apatornis*, and some of the other Cretaceous forms already ned, may also belong to this or an allied family. The teeth *thyornis* (fig. 1117, *a*) are comparatively large, and are set in t sockets; while the centra of the vertebræ are amphicœlous. were about twenty teeth in each jaw, which are directed ob- backwards. The rami of the mandible were but loosely ; and it is probable that the jaws were not sheathed in horn. dult of the typical *I. dispar* (fig. 1116) was about equal in a Rock-pigeon; and in all essential features of its organisa-



17.—*a*, Left ramus of the mandible of *Ichthyornis*, slightly enlarged; *b*, Do. of *Hes-* about one-fourth natural size; *c*, *c′*, Anterior and lateral aspects of cervical vertebra of *nis*, twice natural size; *d*, Tooth of *Hesperornis*, twice natural size. (After Marsh.)

is genus conforms so exactly with the existing Carinate type, ere appears every reason for including it in the same order, than following Professor Marsh's view of placing it, together *Hesperornis*, in a separate order under the name of Odontor-

THLESS SERIES.—In this series, which comprises all existing tes, no teeth are ever functionally developed, although germs in the young of one group.

ORDER 2. CRYPTURI.—The Tinamous (*Tinamus*, &c.) which ute this suborder, show more signs of affinity in the structure r pelvis and skull to the Ratitæ, than is exhibited by any other group of this order. They are confined to the New W and are represented in a fossil state by remains of existing sp of *Crypturus*, *Nothura*, *Tinamus*, and *Rhynchotus*, in the Pleis cave-deposits of Brazil.

SUBORDER 3. IMPENNES.—The Penguins (*Aptenodytes*, &c.) the Antarctic regions form a peculiarly interesting and well-def group of Birds, in which the wings are modified for swimming, the component bones of the tarso-metatarsus are separated by ties. It has recently been proposed that the Impennes should a primary group of equivalent rank with the Carinatæ, under name of Eupodornithes. Unfortunately scarcely anything is kn of their palæontological history, the only fossil type being *P eudyptes* from the Tertiary of New Zealand.

SUBORDER 4. TUBINARES.—The Petrels, or *Procellariidæ*, the only family of this group. The only known fossil represe tives are members of the existing genus *Puffinus* (Shearwater), wh have been recorded from the Lower Miocene of Allier, in Fra and also from the Miocene of the United States.

SUBORDER 5. PYGOPODES.—According to the opinion of fessor Newton this and the two following groups should be rega merely as sections of a single suborder, but since no name has b proposed for this larger group the three divisions are retained. the Pygopodes, the *Alcidæ*, or Auks, include the Great Auk (*A impennis*) of the Arctic regions, which now appears to be totally tinct, but of which the remains are found abundantly in the and other superficial deposits of northern Europe. Remains ferred to the genus *Uria* (Guillemots) are found in the Upper P cene of Italy; and Guillemots also occur in the Tertiary of United States, where they have been described under the nam *Catarractes*. In the *Colymbidæ*, which includes the Grebes Divers, remains of the Red-throated Diver (*Colymbus glacialis*) found in the Pleistocene deposits of Mundesley, in Norfolk; w the extinct *Colymboides* of the Lower Miocene of Allier appear be an allied form.

SUBORDER 6. GAVIÆ.—Of the *Laridæ* (Gulls and Terns) a spe of *Larus* occurs in the Allier Miocene; while *Hydrornis* of the ter deposits may probably be referred to the same family. undetermined genus from the London Clay may perhaps be referable to the present group.

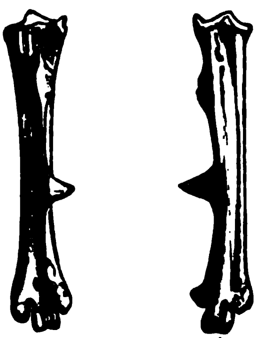
SUBORDER 7. LIMICOLÆ.—The Limicolæ are somewhat a dantly represented in Tertiary deposits; the subaquatic habit many of its members being probably conducive to the preserv of their remains. In the family *Scolopacidæ* the genus *Num* (Curlew) is recorded from the Middle Miocene of Gers, in Fr and the Pliocene of Italy; *Limosa* (Godwit) occurs in the U

The Woodcock (*Scolopax rusticola*) has left its remains in [s]tocene of Westphalia; and a species of *Himantopus* (Stilt) in the Allier Miocene. In the family *Charadriidæ* (Plovers) [s] of the type genus *Charadrius* occurs in the Upper Eocene [a]do; while the genus *Camascelus* (with which *Dolichopterus* [i]probably identical) is known from the Lower Miocene beds [o]n, in France.

[R]DER 8. ALECTORIDES.—The Alectorides form a somewhat [e]d group, which is taken by Mr Sclater to include the although Professor Newton regards the latter as more [l]lied to the Gaviæ and Limicolæ. The family *Gruidæ*, or is represented by the type genus *Grus* in the Pleistocene of India, and the United States, and also in the Lower Pliocene beds of Greece, and the Miocene of Allier. Allied extinct [r]e *Palæogrus* of the Eocene of Italy, and *Aletornis* of that of [g]. The *Otididæ* are represented by a species of Bustard the Allier Miocene.

[R]DER 9. FULICARIÆ.—This suborder comprises the Rails, [W]ater-hens, etc.; all of which are included in the single [R]allidæ, and are of more or less aquatic habits. Birds re- [o] the type genus *Rallus* (Rail) occur in the Montmartre the Miocene of Allier and Gers, and the Italian Pliocene. [s] of *Gallinula* (Water-hen) are recorded from the Pleisto- [d]s of Brazil and Queensland; in both of which deposits [t] with others referred to *Porphyrio* (Purple Water-hen)—a [o]w widely distributed over the warmer regions of the globe. [n]ct species of Coot (*Fulica*) has also been described from [e]nsland Pleistocene. *Notornis*, which occurs in the Pleisto- New Zealand and was also found living some years ago, [g]e Rail allied to the Australian *Tribonyx*; while *Aptornis*, [s] a very large form from the same deposits totally incapable [,] is more nearly related to the existing *Ocydromus* of New

(Pheasants, Turkeys, etc.), and *Tetraonidæ* (Grouse). The
together with the following group of Columbæ were
bracketed together under the name of Rasores, and it i
means certain that the departure from this arrangement is
able one. The skull (fig. 1103, p. 1210) has peculiar palatal
a sharp curved beak, and a recurved process to the angl
mandible. Many of the genera of Gallinæ (especially th
are characterised by the presence of one or more strong bo
on the inner side of the tarso-m
(fig. 1118). The first two famili
present unknown in a fossil condi
the *Phasianidæ*, however, the typic
Phasianus occurs in the Allier a
Miocene deposits, and also in th
Pliocene of Pikermi; *Francolinu*
colin) is represented by remains
ing species in the Pleistocene of
India (fig. 1118); *Coturnix* (Quai
Montmartre Eocene gypsum; th
Palæortyx in both the latter depc
the Isère and Allier Miocene b
so-called *Palæoperdix* of the
Miocene being probably identica
a species of *Gallus*, somewhat lar
the existing Indian *G. Sonnerati*, is
the Pikermi Pliocene. From the Miocene of the United
Turkey (*Meleagris antiqua*) has been recorded, and is desc
equal in size to the living species now characteristic of
In the *Tetraonidæ* remains of the living Capercaillie (*Te*
gallus) occur in the Norfolk Forest-bed; while an extinct
of the same genus has been described from the Upper E
Languedoc. Remains of the existing Willow Grouse (
albus) are found in the Pleistocene of Westphalia.



a b

Fig. 1118.—*Francolinus pondicerianus*. The left tarso-metatarsus; from the Pleistocene of Madras. *a*, Posterior; *b*, Anterior aspect.

SUBORDER II. COLUMBÆ.—This group is taken to inc
existing Sand-grouse (*Pteroclidæ*), and the Pigeons (*Columbi*
the first-named family a species of the type genus *Pterocles*
described from the Allier Miocene. The *Columbidæ* are k
a species referred to *Columba* from the last-named deposits
as by another provisionally referred to the same genus f
Pleistocene of Rodriguez. Of especial interest is a tarso-m
from the Pleistocene of Queensland described by Mr De V
the name of *Progoura*, and regarded as indicating a bird
the Crowned-Pigeons (*Goura*) of New Guinea. *Goura*
some signs of affinities to the *Phasianidæ*, and these reser
are said to be more marked in *Progoura*, which is do

the existing forms. Here also may be placed the now family *Dididæ*, represented by the Dodo (*Didus ineptus*) of us, and the Solitaire (*Pezophaps solitaria*) of Rodriguez.

ese two singular birds, the Dodo formerly inhabited Mauritius numbers, but the last record of its occurrence dates from the 1. It was a large and heavy bird (fig. 1119), bigger than a swan, irely unlike the pigeons in general appearance. The wings were itary and completely useless as organs of flight. The legs were id stout, the feet had four toes each, and the tail was extremely

Fig. 1119.—Skeleton of the Dodo (*Didus ineptus*), restored. (After Owen.

arrying, like the wings, a tuft of soft plumes. The beak (un- of any of the *Columbæ* except the little *Didunculus strigiros-* s arched towards the end, and the upper jaw had a strongly- apex, not unlike that of a bird of prey. The frontal region of was greatly elevated and tumid, from the excessive development ar cavities between the two tables of the skull, and the actual se was very small in proportion to the size of the cranium. In spects allied to the Dodo, and, like it, incapable of flight, was aire, of which the last recorded appearance was in the year The Solitaire had longer legs and neck than the Dodo, the bill strongly arched, its forehead flatter, and there was developed upon the radial side of the metacarpus an extraordinary spherical ca[l]like mass of bone, about as large as a musket-ball, and with a rough[er] surface. This singular callosity is much more developed in cer[tain] individuals—supposed to be males—than in others, which we may [pre]sume to be females; it was doubtless covered during life by a h[orny] integument, and seems to have been used as an offensive wea[pon]. Both these Birds are known to us by nearly entire skeletons obta[ined] recently from the islands which they inhabited; and of the Dod[o we] have also a few remains belonging to entire specimens once preserve[d in] our museums, which were unfortunately allowed to fall into decay, f[rom] apparent ignorance of their priceless value.

Remains of existing species of several genera of *Columbidæ* [are] found in the Pleistocene cave-deposits of Brazil.

SUBORDER 12. ANSERES.—The Anseres, or Goose-like Birds, f[orm] a well-defined subordinal group, characterised by peculiar featu[res] in the palatal region of the skull, and by the perfectly webbed f[eet], the beak being generally broad and spatulate, and the angle of [the] mandible with a recurved process (fig. 1120). All the exis[ting] members of this group are referred to the family *Anatidæ*, wh[ich] is, however, split up into several subfamilies. A peculiar subfa[mily] is represented by the living *Cereopsis*, of Australia; allied to wh[ich] is the much larger extinct *Cnemiornis*, of the Pleistocene of N[ew]

Fig 1120.—Skull of Spur-winged Goose (*Plectropterus gambensis*). Reduced.

Zealand, which was quite incapable of flight. In the subfa[mily] *Anserinæ*, remains of the Grey-Lag Goose (*Anser cinereus*) o[ccur] in the European Pleistocene. The *Cygninæ*, or Swans, are re[pre]sented by the extinct *Cygnus Falconeri*, from the Pleistocene c[ave-]deposits of Malta. In the *Anatinæ* (Ducks) an extinct specie[s of] Tree-duck (*Dendrocygna*) is recorded from the Pleistocene [of] Queensland. Remains of the Wild-duck (*Anas boscas*) occu[r in] the Pleistocene of Europe; *A. atavæ* and *A. cygniformis* are fo[und] in the Middle Miocene of Bavaria, the latter species being n[early] as large as a Swan; *A. œningensis*, from the Upper Miocen[e of] Switzerland; *A. lignifila*, from the Middle Miocene of Italy; [and] *A. Blanchardi*, from the Allier Miocene. Remains of the Shov[eller] k (*Spatula clypeata*) have been found in the Norfolk Forest-. In the *Fuligulinæ*, the type genus *Fuligula* (Pochard) is rded from the Upper Pliocene of the Val d'Arno, in Italy, *Nyroca* (White-eyed duck), from the Pleistocene of Queens-d; while in the *Merginæ*, it is probable that *Mergus* (Merganser) represented in the Pliocene Siwaliks of India. The extinct *ornis*, of the Italian Miocene, also belongs to this family, ough its precise position is uncertain.

SUBORDER 13. ODONTOPTERYGES.—The *Odontopterygidæ*, repre-ted by *Odontopteryx*, of the London Clay, appear to indicate a inct subordinal group, which may be provisionally placed here. this singular bird the alveolar margins of both jaws are furnished h tooth-like serrations (fig. 1121) which differ from true teeth being actually parts of the osseous substance of the jaw itself, thereby agree with those found in the Chelonian genera *Har-a* and *Batagur*. They are of triangular or compressed conical

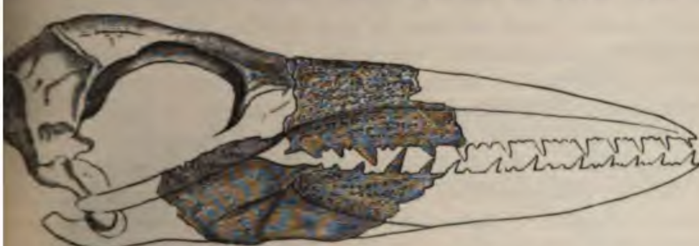


Fig. 1121.—Skull of *Odontopteryx toliapicus*, restored; from the London Clay. (After Owen.)

m, and of two sizes. Upon the whole, *Odontopteryx* would pear to be most nearly allied to the *Anatidæ*, but the serration of jaws is an entirely unique character, unknown in any existing pe.

SUBORDER 14. PALAMEDEÆ.—Of this group, comprehending only American Screamers (*Chauna*, &c.), no fossil representatives are own.

SUBORDER 15. ODONTOGLOSSÆ.—The only family of this group the *Phœnicopteridæ*, or Flamingos, which are exceedingly long-bed waders, distinguished by a peculiar downward bend of the k, and presenting characters connecting them on the one hand h the Anseres, and on the other with the Herodiones. The ting genus *Phœnicopterus* is found in the Allier Miocene; while the same beds, as well as in the equivalent deposits of the vence basin, and also in the somewhat higher strata of Stein-n, in Bavaria, occurs the peculiar genus *Palælodus*, which, le apparently allied to *Phœnicopterus*, presents some affinity to the Limicolæ, and also shows one osteological feature now occurring among the *Pygopodes* in *Podiceps* (Grebes) and *Col* (Divers). *Elornis*, from the Lower Miocene of Ronzon, a to be also allied to the Flamingos; while *Agnopterus*, fro Upper Eocene of Montmartre, may perhaps be also includ the present group.

SUBORDER 16. HERODIONES.—This suborder includes the *P leidæ*, or Spoonbills and Ibises; the *Ciconiidæ*, or Storks; an *Ardeidæ*, or Herons; all of which are waders. The *Plataleid* represented in past epochs by an extinct species of *Ibis* (*I. pag* from the Allier and Steinheim Miocene; while the existing A Black-headed Ibis (*I. melanocephala*) has left its remains (fig. 1 p. 1217) in the Pleistocene cave-deposits of southern India. other existing species of this genus occurs in the cave-depos Brazil. In the *Ciconiidæ*, an extinct species of the African Oriental genus *Leptoptilus* (*Argala*), which includes the Adjutant Stork of India, is found in the Pliocene Siwaliks of latter country, and another in the Middle Miocene of Bavar while an undetermined Ciconioid, from the Pikermi beds Attica, may possibly belong to the same genus. Part of a me tarsus, from the Tertiary of Argentina, indicates a bird double size of the Pampean Stork, and has been made the type of genus *Palæociconia*. The Indian Siwaliks have also yielded re of another giant Stork, of which the genus has not yet been de mined. In the Pleistocene of Queensland there occurs an extin species of *Xenorhynchus*. In the *Ardeidæ* the type genus *Ard* (Heron) is represented in the Bavarian Miocene by a species (*A similis*) apparently closely allied to, but rather stouter than, th common Heron (*A. cinerea*); and remains of the same genus al occur in the Miocene of Allier and Gers. The Night-Hero (*Nycticorax*) are known by an extinct species in the Pleistocene d posits of the Island of Rodriguez. Finally, certain remains fro the London Clay may possibly indicate that this family dates fro that epoch.

SUBORDER 17. STEGANOPODES.—In the Steganopodes are i cluded a number of web-footed Birds, such as the Darters (*Plotid* Cormorants (*Phalacrocoracidæ*), Albatrosses and Frigate-Birds (*Fr gatidæ*), and the Pelicans (*Pelicanidæ*), some of which are regarde as more or less closely allied to the Gaviæ, while it is suggeste that there may also be a connection between this group and th Accipitres. The *Plotidæ* are only known in a fossil state by species of the one genus *Plotus*, from the Pleistocene of Queen land. In the *Phalacrocoracidæ* we find the type genus *Phal crocorax* (*Graculus* or *Cormoranus*) in the Eocene of Montmart the Allier Miocene, the Pliocene of the United States, and pro also in the Indian Siwaliks; remains of the existing Cormorant *arbo*) being found in the Norfolk Forest-bed. *Sula* (Gannet) ars in the Miocene beds of Colorado and of Ronzon (Puy-en-ay); while *Pelagornis*, of the Allier Miocene, is provisionally ed in this family. In the *Fregatidæ* remains of a *Diomedia*, arently closely allied to the Albatrosses of the Southern seas, e been described from beds at the top of the Suffolk Crag; le it is considered probable that *Argillornis*, of the London y, indicates the existence of this family in the Lower Eocene. the *Pelecanidæ* remains of true Pelicans (*Pelecanus*) occur the Miocene of Allier and Bavaria, as well as in the Indian aliks.

UBORDER 18. ACCIPITRES.—The Accipitres, or Diurnal Birds Prey, are characterised by their curved beak (fig. 1122, B), the ence of a circle of feathers round the eye, and the powerful ns of the foot (fig. 1122, A), as well as by many osteological ures, and especially the nearly straight line formed by the three

Fig. 1122.—A, Foot of the Peregrine Falcon; B, Head of Buzzard. Reduced.

ninal trochleæ of the tarso-metatarsus (fig. 1123), and the ab-ce of a bony bridge over the extensor tendons at the distal remity of the tibia. The probability of this group being related the Steganopodes has been already noticed. The *Cathartidæ*, American Vultures, are represented by existing species of *Cath-es* and *Gyparchus* in the Pleistocene of the Brazilian caves. It also been considered that this group is represented in Europe *Lithornis vulturinus*, of the London Clay; an opinion which, if firmed, will be of considerable interest from a distributional nt of view. The peculiar *Serpentariidæ*, or Secretary Vultures, Africa, are known by a species of the one existing genus *Ser-tarius* from the Allier Miocene. The *Falconidæ* include all the aining genera, which are grouped in several subfamilies. Of se the *Vulturinæ*, or true Vultures, are represented in the Pleis-ene breccia of Sardinia by remains of the type genus *Vultur*; le those of the existing Afro-Indian *Neophron percnopterus* are recorded from the equivalent cave-deposits of southern India. the other groups we have evidence of a species of either *Milvu* *Circus* (fig. 1123) from the last-nam deposits, the figure being given in ord to show the form of the distal end of t tarso-metatarsus so characteristic of t suborder. *Milvus* is recorded from t Allier Miocene; and *Falco* from t Montmartre Eocene. Species refer to *Aquila* are mentioned both from t Miocene of Allier and Gers, and t Sardinian Pleistocene; while *Haliæ* is recorded from Gers. Of ext genera *Palæohierax*, from the Alli Miocene, is regarded as being allied *Aquila*; while *Palæocircus*, of the Montmartre Eocene, is descri as showing affinity to the Buzzards (*Buteo*), and the Osprey (*Pa dion*); *Teracus*, from the Ronzon Miocene, being an imperfec known form. The largest known member of this suborder *Harpagornis*, from the Pleistocene of New Zealand, which apparently allied to *Circus*. Finally, several existing species *Falconidæ* are recorded from the Pleistocene of the Brazil caves.

Fig. 1123.—(?) *Milvus* or *Circus*, sp. The distal half of the left tarso-metatarsus, from the anterior (A) and posterior (B) aspects; from the Pleistocene of Madras

SUBORDER 19. STRIGES.—The Striges, or Owls, were form

Fig. 1124.—A, Foot of the Long-eared Owl (*Otus vulgaris*); B, Head of the same. Redu

grouped with the Accipitres, but are now regarded as being pr ably more nearly allied to the Parrots. Comparatively few fo forms are known; but in the *Asionidæ*, or Eagle-Owls, we have ıgle-Owl (*Bubo ignavus*) in the Norfolk Forest-bed, and ting Indian *B. coromandus* in the Pleistocene of Madras; is genus is also recorded from the Allier Miocene, and is ıted in the Eocene of the United States by *B. leptosteus*, ras about two-thirds the size of the existing *B. virginianus* habiting the same regions. The existing Ceylon Fish-*etupa*[1] *ceylonensis*) occurs in the Pleistocene of Madras, and at European Snowy Owl (*Nyctea scandiaca*) in that of West-

In the *Strigidæ*, or true Owls, remains of an extinct species *ine* have been described from the Pleistocene of the Island lriguez; while bones from the Miocene of Allier and Gers een referred to *Strix*.

ORDER 20. PSITTACI.—The Parrots, Cockatoos, and their which constitute this suborder, are now confined to the r regions of the globe, and are remarkable for the presence nge-joint at the base of the strongly-curved cranial portion of ak, whereby the upper jaw can be moved upon the cranium , as is shown in fig. 1125, A. All the genera are of scansorial

25.—Right lateral aspect of the skull (A) and of the left pes (B) of *Psittacus erythacus*. uced. *a*, First (hallux); *b*, Second; *c*, Third; *d*, Fourth digit. (After Blanchard.)

, and the foot has a hallux (fig. 1125, B). In the *Psittacidæ*, e Parrots, remains from the Allier Miocene have been referred typical African genus *Psittacus*, but that term must be used ider sense than the one in which it is employed by the students ent Ornithology. *Lophopsittacus* is an extinct genus from the ocene of Rodriguez. Remains of the genus *Nestor*, peculiar w Zealand, occur in the deposits of that country which yield *rnis*, and probably belong to existing species. The American ws are represented by species of *Ara* in the Brazilian cave-its. In the *Palæornithidæ*, which includes the Lories and eets, an extinct species of the existing African and Oriental *Palæornis* occurs in the Pleistocene of Rodriguez, which has yielded the extinct *Necropsittacus*. The *Stringopidæ* of New

[1] Amended from *Ketupa*.

Zealand, and the *Cacatuidæ* (Cockatoos) of Australia, have been recorded in a fossil state.

SUBORDER 21. PICARIÆ.—The *Picariæ* are a somewhat geneous group of Birds, of which it will be unnecessary to all the families, since only a few are definitely in a fossil co To the African *Musophagidæ*, or Plaintain-cutters, it is thou extinct *Necrornis*, from the Miocene of Gers, may possibly The remarkable *Leptosomatidæ*, of Madagascar, which con *Coraciidæ* with the *Cuculidæ*, are represented by a species type genus *Leptosoma* in the Allier Miocene. The latter have also yielded a species of *Trogon*, the type of the fam *gonidæ*. *Limnatornis*, of the same beds, is referred to the U or Hoopoes; while it is considered that the Upper Eocene *nis* may belong to the *Bucerotidæ*, or Hornbills, of the E and Oriental regions. The *Alcedinidæ*, or King-fishers, ar sented in the London Clay by *Halcyornis;* while in the (Woodpeckers) we have the existing genus *Picus* in the Miocene of Isère and the Lower Miocene of Allier, and the *Uintornis* in the Eocene of Wyoming. Finally, the *Cyps* Swifts, are known to have existed since the Allier Miocen we find a species of the type genus *Cypselus* closely allied to forms.

SUBORDER 22. PASSERES.—Of the Passeres, the last a highly organised group of the class, an enormous number genera and species are known; but from the comparative size of the majority of species, and the difficulty of distin even genera by fragmentary bones, scarcely anything is k their palæontological history. To the *Alaudidæ* (Larks) h provisionally referred *Protornis*, from the Lower Eocene of in Switzerland; and *Alauda* is recorded from the Upper of Italy. In the *Corvidæ* (Crows) the type genus *Corvus* h described from the Allier Miocene. In the Pleistocene of R the extinct *Necropsar* is a Starling (*Sturnidæ*) closely allied pied and crested *Fregilopus* of Reunion, which also appears recently become extinct. Among the *Fringillidæ* (Finches and *Passer* are provisionally recorded from the Allier Miocer to this family may perhaps be referred the extinct genus *Pal* from the Upper Eocene of Colorado. Finally, we have sentative of the *Laniidæ*, or Shrikes, in a species of *Lani* the Allier Miocene; while the *Sittidæ* (Nuthatches) date the ence at least from the fossil *Sitta* of the Montmartre Eoce are also represented by a species in the Upper Pliocene Lastly, the cave-deposits of Brazil have yielded remains of existing forms of Passerines, among which it will suffice to a species of Swallow (*Hirundo*).

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CHAPTER LVIII.

CLASS MAMMALIA.

GENERAL STRUCTURE.

Mammalia, or highest class of the Vertebrata, are character-by having some part of the integument provided with hairs at : period of life, and by the young being nourished for a longer iorter time by the milk, or special secretion of the mammary ds. As characters available in the case of fossils, it may be rved that the cranium articulates with the atlas vertebra by two pital condyles, mainly formed by the exoccipitals; while each is of the mandible consists of only a single piece, which proxi-y articulates directly with the squamosal element of the cranium out the intervention of a quadrate; and there is no movable : between the proximal and distal rows of the tarsus. Like the opsida, Mammals possess during development an amnion and itois, and are totally devoid of gills. They differ from Reptiles agree with Birds in having a four-chambered heart, warm blood, a complete double circulation. They are peculiar in that the corpuscles of the blood are not nucleated and usually circular; ie lungs being freely suspended in the thoracic cavity, which is rated from the abdomen by a muscular partition termed the *hragm;* in the presence of only the left aortic arch; and in the :ction of the transverse commissure (corpus callosum) connect-the two cerebral hemispheres. Feathers, moreover, are never ent, and there is no *syrinx* or lower vocal organ, although mplete *larynx* is always developed in the upper portion of the *ea*, or respiratory tube.

will be unnecessary in this work to make any further mention ie soft parts, but a few remarks must be made concerning the mentary and dental systems, and the endoskeleton; although student must refer to other works for fuller information on these ects. With regard to the tegumentary system, it will suffice to observe that imbricated horny scales occur in the epidermis c the family *Manidæ* among the Edentata; and flat horny sl with their edges in apposition, in the tails of the Beaver, Rat certain Insectivores and Marsupials. The Armadillos and G donts develop, however, a series of bony scutes articulating one another in the true dermis, which are covered by horn dermal shields; the whole structure being thus precisely comp to that obtaining in the Crocodilia. Smaller separate bony also occur in the dermis of *Mylodon*. The horns of the Rumi and Rhinoceroses are entirely epidermal structures; the fi being hollow sheaths enveloping bony cores, while the latt solid throughout.

The dental system, as being of extreme importance for the mination of the extinct forms, must be noticed somewhat more Calcified teeth are developed in the great majority of Mammal in the true Whales they occur only in the embryo, in *Ornithorh* they disappear in the adult, while in *Echidna*, *Manis*, and *A cophaga*, no traces of them have as yet been detected. In the of *Ornithorhynchus* and *Rhytina* the function of teeth is discl by horny plates, or *cornules* on the palate. In all other forms ever, true teeth, which are developed only in the premaxilla, m and dentary bones, are present; and are usually composed three elements, dentine, enamel, and cement, although occasi as in the existing Edentates, the enamel is absent. The de or ivory, forms the chief constituent of most teeth. This is c either completely or partially, in the majority of cases by a th vesting layer of the hard flint-like enamel, which is readily guished from the dentine by its bluish-white and translucent a ance, while the outermost coat of cement, when present, is of opaque white, or buff, colour. The cement is frequently found as a thin coating at the roots of the teeth; but it is very l developed in the crowns of the hinder teeth of many Ung In the teeth of the great majority of Mammals (as in fig. 112 crown, or exposed portion, is sharply defined by a constr known as the *neck* from the root, or embedded portion; but in teeth to be immediately noticed, which grow continuously, th no such distinction between the crown and the root. In no mals are the teeth anchylosed to the bones of the jaw;[1] and are invariably implanted in distinct alveoli, or sockets, whic however, very imperfect in certain Cetacea. In all young an while the teeth are still growing, the inferior extremity of the or roots, is widely open; but in the majority of instances this ture becomes completely closed in the adult (fig. 1126). In c

[1] Except, perhaps, the incisors of the Shrews.

however, as in the anterior cutting-teeth of the Rodents and sks of the Elephant, the root remains permanently open be- nd the tooth consequently continues to grow throughout the f the animal. In such circumstances the teeth are said to have stent pulps. The anterior teeth (fig. 1126, *c*, *i*), with some exceptions, are of simple structure and have but a single root; he hinder ones (*ibid.*, *pm*, *m*) very generally have more or less plex crowns, which may be supported by from two to four roots; division of the roots being unknown outside the Mammalian . In many forms the summits or sides of the crowns of the ler teeth may be interpenetrated by deep re-entering folds of mel, which may be filled up with cement; these folds being espe-

Fig. 1126.—Teeth of the right side of the lower jaw of the Chimpanzee. *i*, Incisors; *c*, Canine; *pm*, Premolars; *m*, True molars. (After Owen.)

lly developed in many Rodents and Ungulates. From this ucture it will naturally result that when a horizontal section of the own of such a tooth is made by the wearing of the upper against e lower series, an extremely complex pattern will appear, as will seen in the figures of the cheek-teeth of the above-mentioned oups which are given below. Much more rarely, as in the Horse, ere may be an infolding of the enamel in the summits of the owns of the anterior teeth.

With the exception of the above-mentioned edentulous forms, in existing Mammals one definite set of teeth, which is almost ays constant in number, is developed, and this set when it ap- ars usually persists throughout the remaining portion of the life its owner. In a large number of species this is the only set ever veloped; and such species, or groups of species, are consequently d to be *Monophyodont.* In the greater majority of Mammals, wever, the development of occasionally only one, but usually of greater number of the anterior teeth of this permanent set is

retarded, and their function filled for a time by an earlier
of so-called milk-teeth; such Mammals being accordingly te
Diphyodont. As development proceeds the permanent teeth in
Mammals come up beneath the milk-teeth, and thus replace
in a vertical direction; but there are instances where certain of
milk-teeth have no such permanent successors, while in other c
the anterior teeth which come into use with the permanent de
tion have no milk predecessors. Those Mammals with a M

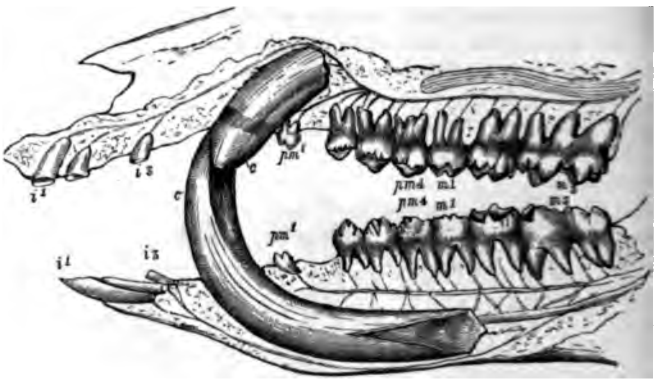


Fig. 1127.—Outer lateral aspect of the left dentition of the Pig (*Sus scrofa*), with the
lamina of bone removed, in order to exhibit the roots of the teeth. *i*, Incisors; *c*, Canine;
Premolars; *m*, True molars.

phyodont dentition present the least specialised development, sin
the milk-series appears from the latest researches to be an additi
grafted on to the permanent one; and there is accordingly no hom
logy between this definite single replacement and the irregular co
tinuous change which takes place in many Reptiles. In some Ma
mals, like the Dolphins (*Delphinidæ*), all the teeth are so much ali
that they cannot be divided into groups, and the dentition is th
described as *Homœodont;* but in the majority the permanent teet
either from their position or their mode of succession, can be sep
rated into four distinct groups (as in figs. 1126, 1127), and the de
tition is then termed *Heterodont.* In Eutherian Diphyodont Ma
mals the total number of teeth of the permanent series does n
normally exceed 44; and in forms like *Sus* (fig. 1127), or the
tinct *Anoplotherium*, where this full complement is present, the fi
three upper teeth (*i* 1-*i* 3) on either side, which are situated in t
premaxillæ, are termed *incisors;* the last three (*m* 1-*m* 3), which
distinguished by having no milk-predecessors, *true molars;* the fo
submolariform teeth (*pm* 1-*pm* 4) in advance of the latter, of whi
the last three have such deciduous predecessors, *premolars;* a

e subconical tooth (*c*) situated between the premolars and ors the *canine;* the latter tooth being the first of those y the maxilla. The same terms are applied to the corre- lower teeth, although it will be unnecessary here to indicate h serial correspondence is worked out. For the sake of such a dentition may be expressed by the numerical

$$—I. \frac{3—3}{3—3};\ C. \frac{1—1}{1—1};\ Pm. \frac{4—4}{4—4};\ M. \frac{3—3}{3—3} = 44;$$ but

teeth of opposite sides of the jaws always correspond, such a may be further simplified into—

$$I. \frac{3}{3};\ C. \frac{1}{1};\ Pm. \frac{4}{4};\ M. \frac{3}{3} = 22 \times 2 = 44.$$

ividual teeth of each group are enumerated from before ds, and by such a formula as the following—viz.,

$$\frac{2,\ I.\ 3,\ C.,\ Pm.\ 1,\ Pm.\ 2,\ Pm.\ 3,\ Pm.\ 4,\ M.\ 1,\ M.\ 2,\ M.\ 3,}{2,\ I.\ 3,\ C.,\ Pm.\ 1,\ Pm.\ 2,\ Pm.\ 3,\ Pm.\ 4,\ M.\ 1,\ M.\ 2,\ M.\ 3,}$$

individual tooth can be specially noted. Thus, for example, ill indicate the first upper premolar, and $\overline{m.\ 3}$ the third, or er true molar. It will frequently, moreover, be convenient k of the incisors and the canine collectively as the *cutting-*, the premolars and true molars as the *cheek-teeth.* It is very ly the case that when the true molars are reduced to less hree it is the hinder tooth, or teeth, that disappear; in the ars it is, however, frequently the anterior teeth that are want- though this is by no means invariably the case, and there are ces known where the second and fourth disappear, while the nd third remain. In the figure of the lower dentition of the panzee given on page 1247, the two premolars are usually ned as $\overline{pm.\ 3}$ and $\overline{pm.\ 4}$, but it is not certain that such is the case. Again, it has been suggested that the two incisors in that species, in common with other Primates, may be the nd third of the typical Eutherian series of three, although other rities regard them as the second and third. It may also be ob- l that in some groups, as the Carnivora, the specialised forms o lose the molars and retain the full number of anterior teeth; in others, like the Ungulates, the reverse condition obtains.

e milk-dentition may be expressed by a similar formula with efix of the letter *M.* to the symbols. The typical milk-series hus be written as $M.i.\ \frac{3}{3},\ M.\ c\frac{1}{1},\ M.m.\ \frac{3}{3}$; the three milk- s corresponding to the last three premolars of the permanent In a few Ungulates, however, such as *Tapirus*, and some- *Rhinoceros* and *Palæotherium*, four milk-molars are developed.

Among the existing Metatheria the number of true mol generally $\frac{4}{4}$, while the premolars are very frequently reduc number, and there may be five upper incisors. In one ex and several Mesozoic members of that subclass, the number of molars exceeds four; but, with the possible exception of so these extinct types, there is no known instance of a heter Mammal normally having more than four premolars; and is never more than a single canine tooth on either side of jaw.

Since in Ungulates it is sometimes difficult to distinguish m from premolars, it may be well to mention how the division be the two series can always be determined. Since the first tooth of true molar series always comes into use before the last milk-mo shed, it is obvious that in the adult the first true molar will a be more worn than the last premolar. Thus, in the three tee *Hipparion* represented in fig. 1233, the tooth on the left sid the figure being more worn than the one in the middle is th shown to be the first of the true molar series; the other two l consequently premolars.

The different types of cheek-teeth will be mentioned under head of the various orders and families, but a few general obs tions may be recorded here. Professor Osborn considers that primitive Mammals had simple conical teeth with undivided fa and that the crowns of the teeth of the upper and lower jaws tually interlocked. Teeth nearly approaching to this type occu the Triassic *Dromatherium* (fig. 1140), while those of the Dolp are looked upon as a reversion to this type. Another simple ty according to the views of the same author, is that found in *Tric don* and *Priacodon* (fig. 1147), where the upper and lower te alike consist of three cusps in a line; the upper teeth biting on outer side of the lower. A third common, and apparently generalised, type of tooth is that known as the *tritubercular.* T consists in the upper teeth of one inner and two outer cusps, ranged in a triangle; while in the lower jaw the reverse arrangem obtains, so that there is one cusp on the outer and two cusps on inner side of the crown. An example of this type of structu its simplest form occurs in the Mesozoic genus *Spalacother* Modifications of this type occur in the lower teeth of many M pials (*e.g.*, fig. 1145), and also in the lower carnassial teeth of Carnivora, of which mention is made in the sequel. The trit cular type of tooth is regarded by the American Palæontologis one which has given rise to a large number of the more con modifications; and it is extremely common among the gener Mammals of the Lower Eocene.

Iammals, as in the Sauropsida, the whole of the primi-
nous cranium is replaced by extensive ossifications,
: ethmoidal region; and these bones, with the excep-
e of the mandible, hyoid arch, and internal auditory
e similarly articulated together at their edges by suture.
s on there is generally a tendency to the obliteration of
s, this being most marked in *Manis*. In all cases the
d has ceased to exist as a distinct ossification. It has
observed that the hinder part of the cranium articulates
st, or atlas, vertebra by two exoccipital condyles, and
ch of the two rami of the mandible is composed of a
articulating at its proximal or hinder extremity with the
of the cranium. Owing to the complete incorporation of
sal and parietal in the walls of the brain-case there is
Birds) no superior temporal arcade; but an inferior, or
arcade is nearly always present; and, as in Crocodiles
ot in Birds), forms the lower border of the orbit. This
poral arcade, or arch, differs, however, from that of most
in that its jugal element articulates directly with the
in which respect it accords with that of the Dicynodont
nd should be known as a squamoso-maxillary arcade.
to the view of Professor Huxley, the Sauropsidan quad-
een taken up into the inner ear to form the malleus.
ntly, however, other writers have taken a different view,
ling to Dr Baur, the representative of the quadrate is to
n the zygomatic process of the squamosal, with which the
ulates; the quadratojugal being also represented at the
f these two bones. Dr Gadow, however, disputes this
finds the representative of the quadrate in the tympanic
determination according with the view here taken as to
ogy of the zygomatic arcade, which appears to have no
gal element.

when, as in the Primates and many Ungulates, the orbit
l posteriorly by a bony postorbital bar, the ascending pro-
e jugal articulates directly with the frontal, without the
n of the postorbital or postfrontal, which forms such a
s feature in the Reptilian skull.

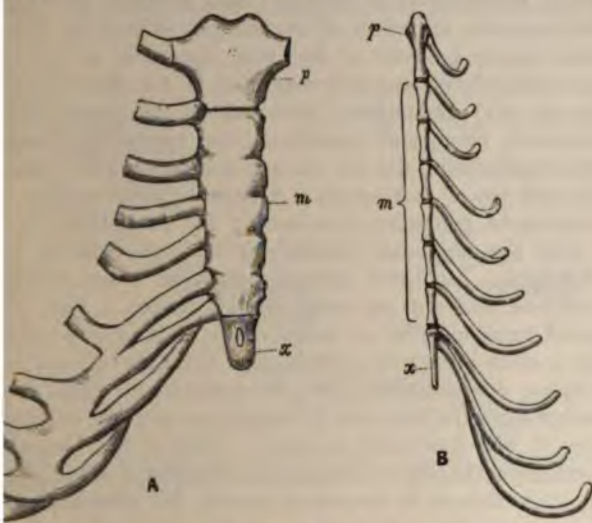
cases the premaxillæ, maxillæ, and palatines develop in-
tal plates which meet in the median line below the nasal
d thus completely separate the latter from the cavity of
. Except, however, in the Anteaters (*Myrmecophaga*), in
of Armadillo (*Tatusia*), in certain Cetaceans, and in one
Hyænodon, this flooring of the nasal passage does not
ckwards to include the pterygoids, as it does in modern
ns. The palatines are always placed behind the maxillæ.

Finally, the sclerotic of the eyeball never develops a ring of plates like that so frequently found in the Sauropsida.

A characteristic feature of the larger bones of Mammals, al one by no means peculiar to the class, consists in their o from several distinct centres. In the case of the long bo shaft is formed by one centre of ossification, while two disti ments termed epiphyses form the extremities; in the adult the of these being welded together into a solid mass. The long are also tubular, and their vacuity is filled with the fatty marro

The vertebræ always have well-developed articular process their arches; the ends of the centra are generally flattened, b the cervical region of certain Ungulata they may be opisthoco Terminal epiphyses, so generally wanting in the Sauropsid nearly always present. The number of vertebræ varies gr owing to the great difference in the length of the tail in dif species; but in the majority of Mammals the number of prec vertebræ does not vary very far from thirty, although in *I* and *Cholœpus* their number reaches forty. In spite of the difference in the length of the neck in different Mammal number of cervical vertebræ in existing forms is, with three n exceptions, seven. These exceptions are *Manatus australi* *Cholœpus Hoffmanni*, in which the number is reduced to si *Bradypus tridactylus*, in which it is increased to nine. A ing, however, to Professor W. K. Parker there may occasi be eight cervicals in the Pangolin (*Manis*). The first, or vertebra always has two articular cups for the occipital con and, except in certain Cetacea, the second, or axis, has a w fined odontoid process. Usually the cervical vertebræ are free; but they are anchylosed together in some of the Cetace in the Armadillos. The dorsal vertebræ are usually well de from the lumbar, although this is not invariably the case; an number of dorso-lumbars in any one given group is usually constant, and among the Ungulata affords assistance in classific A distinct sacral region is present in all Mammals except th tacea, where the iliac bones are absent. The number of c vertebræ varies from three (certain Primates) to forty-six (*M* Chevron-bones are present in the caudal region of many long-t forms. The sternum is always present, although varying grea form. It usually consists of a *presternum* (fig. 1128, *p*) and posterior *xiphisternum* (*x*), between which are a varying numb segments (*m*) constituting the *mesosternum*. The segments of mesosternum (fig. 1128, A) may be anchylosed together; an the *Balænidæ*, among the Cetacea, only the presternum is pre The connection of the ribs with the sternum is generally by c lage; but in the Armadillos the costal cartilages ossify, and are

ternal ribs. In the anterior dorsal region the capitular
e ribs articulates with the vertebræ in a pit at the junction
tra, while the tubercular head joins the transverse process
ond of these two vertebræ; but in the posterior dorsal
two heads generally coalesce. Dr Baur regards the
ral articulation of the capitula in the anterior region as a
ival of the intercentral attachment of the ribs of primitive
ed to Theriodont Anomondontia, which has been totally
g other Reptiles; and the mode of costal articulation is



A, Sternum and right costal cartilages of Man; B, Sternum and left costal cartilages of Dog. *p*, Presternum; *m*, Mesosternum; *x*, Xiphisternum.

edly very near to that of those Anomodonts which have
intercentra. Uncinate processes are never present on the

Mammals the pectoral limb is well developed. The pec-
dle is, however, usually simpler than in lower forms; the
persisting as a distinct bone only in the Monotremata,
owever, it anchyloses to the scapula. An interclavicle is
only in the last-named order; where it articulates with the
after the Reptilian manner. In the Eutheria the clavicles
in their complete development in those groups, such as the
ora, many Rodentia, the Chiroptera, and the Primates,
se the pectoral limb for flight, burrowing, or prehension.
nerus frequently has an entepicondylar foramen, like that of
modont Reptiles. The radius and ulna retain their original

pre- and postaxial position in the Cetacea; but in most mals they are crossed at their distal ends, so that the become reversed, and in the "prone" or normal position the radial, or preaxial border of the hand, becomes intern Primates, however, these bones admit of motion upon or and when the hand is "supine" (that is, with its palm d wards or upwards), the bones of the fore-arm occupy th primitive position. In the majority of those Mammals w are adapted solely for walking, the ulna is more or less re the radius, especially at its proximal end, is much enlarg it articulates with the whole of the anterior surface of the and thus comes in front of the ulna, instead of at its s .carpus essentially corresponds with that of the type repr fig. 829 (p. 907); the radiale,[1] intermedium, and ulnare be the scaphoid, lunar, and cuneiform; the trapezium, trap magnum representing the 1st, 2d, and 3d carpalia, and th the 4th and 5th of that series. A centrale is present in of embryos of pentedactylate forms; but in the adult fuses with the scaphoid, although it remains distinct i the Primates. In some groups others of these elen also coalesce, and one or more may be absent. The p presumed representative of the seventh digit, is general veloped; while in pentadactylate types there may be an representing the prepollex. The metacarpals and digits n in number (Proboscidea and Primates), or may be reduc or even to one functional member. Among the Ungu the metacarpus is reduced to a single functional element Horse, such element is frequently termed the *cannon-bon* tomy, however, this term is more usually restricted to th dium of those Artiodactyla which consists of the coale and fourth metapodials. Except in the Cetacea there more than three phalangeals to each digit, but by supp anchylosis this number is occasionally reduced; and the (pollex) has but two phalangeals. The pelvic girdle is developed in all Mammals except the Cetacea and Sireni the adult the three elements coalesce to form an *innomi* The pubis and ischium of the same side always unite to e obturator foramen; and the two pubes meet in a ventral which is, however, not completely united in certain Insect a large number of instances the ischia meet in a ventral

[1] Since the preceding chapters were in type, Dr Baur has expressed that the bone termed radiale in fig. 829 is really a second centrale; radiale is represented by a minute bone generally known as the radii The Mammalian scaphoid is accordingly also regarded as a second c the same communication, Dr Baur expresses his disbelief in the exist nants of a prepollex and of a seventh digit in Mammals and other Ve

greatly elongated in some Ungulates (fig. 1128 *bis*), but in nates and some other forms there is no such union. In the emata and Marsupialia epipubic, or *marsupial*, bones are l to the anterior border of the pubic symphysis (fig. 1139). nur may have a third trochanter (fig. 1226) for the attach- one of the gluteal muscles. The tibia and fibula are never at their distal extremity, but lie in their primitive parallel ; the tibia, or preaxial bone, being internal in the usual position, and the fibula external. The latter bone may be less rudimentary, and completely anchylosed at one or both

128 *bis*.—The left side of the pelvis of the Eland (*Oreas canna*). One-sixth natural size. ; *is*, Ischium ; *s*, Symphysis of do. ; *a*, Epiphysis on symphysis of ischium and pubis ; s ; *ob*, Obturator foramen.

nities to the tibia. The patella is present in all except some theria. If the pes (fig. 1129) be compared with the typical s mentioned on p. 907, it will be found that the fibulare is sented by the calcaneum, which may also contain an element sponding to the pisiform of the manus ; the astragalus has usually regarded as the coalesced tibiale and intermedium, is thought by Dr Baur to correspond solely to the latter ; ento-, meso-, and ectocuneiform represent the 1st, 2d, and 3d lia ; while the 4th and 5th tarsalia have coalesced to form the ids. The centrale persists as the navicular, which may unite the cuboid.[1] Other modifications occur analogous to those e carpus ; but in no instance, as already observed, is the joint een the leg and the pes formed on the line between the proxi- and distal rows of the tarsus. The metatarsals and phalan-

r Bardeleben has pointed out to the writer that in *Cryptoprocta* there may be nd centrale, which usually coalesces with the ectocuneiform.

geals repeat the characters of the homologous bones of th although they deviate in a lesser degree from a comm In the Cetacea and Sirenia the pes is entirely absent; alth proximal portions of the pelvic limb may be detected in an form in many genera.

We may now take a brief glance at the general distril time of the Mammalia, in the course of which we shall have stall some of the information given in the sequel.

If the theory of evolution be the true explanation of t of nature we should expect to find that the earliest repres of the class would be smal more or less closely related another, not numerous in gener and allied to those orders wh comprise the most generalise sentatives of the class. Our kr of these earlier types is indeed ingly imperfect, but so far as i appears to accord fairly well foregoing conditions; all the forms being of small size, an ently more or less closely allie existing Marsupials, and prob to the Monotremes and perl Insectivores. The earliest evi the occurrence of Mammals ye is in the upper portion of the system, which forms the base great Mesozoic period. Of known genera from these dep larger type, termed *Dromather* hibits some curious approximations in the structure of its Reptiles and Amphibians, and it is possible that we may this form an ancestral type of the Prototheria. In th Jurassic, immediately above the Lias, remains of small M become more common, and in the Upper Jurassic they ar abundant, although they comprise comparatively few gener These Jurassic Mammals are readily divisible into two group guished by the characters of their teeth. Of the first grou ample of the lower jaw is shown in fig. 1141, p. 1274, whe be seen that the teeth are very numerous, the hinder one several sharp cusps on the crowns. Although there has be discussion as to the affinities of these small Mammals, it is that they are really Marsupials of the suborder Polypro with a relationship to the Australian Anteater (*Myrmecobius*

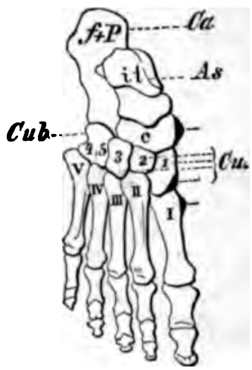


Fig. 1129.—Dorsal aspect of the right pes of Man. Reduced. *Ca*, Calcaneum (fibulare + ? pisiform); *As*, Astragalus (intermedium); *c*, Navicular (centrale); *Cu*, 1-3, Ento-, meso-, and ectocuneiform (1st, 2d, 3d tarsalia); *Cub*, Cuboid (4th, 5th tarsalia); i-v, Metatarsals. (After Wiedersheim.)

nall see in the sequel, is the only existing heterodont with more than four true molars. In the second group tition is of a very different type; the lower jaw having a pair of curved and chisel-like incisors, separated by an from the cheek-teeth, which are characterised by the e of one or more longitudinal grooves. The serial position group, which has been named Multituberculata, is still o doubt, but not improbably it may indicate an extinct order totheria.

roughout the greater part of the Cretaceous period our know-e of Mammalian life is a blank, doubtless owing to the circum-ce that the greater portion of the Cretaceous beds, such as the lk, is of purely marine origin; but evidence has recently been ined of the existence of a Mammalian fauna in the topmost taceous of North America allied to that of the Jurassic.

Vith the dawn of the Tertiary period, which may be regarded as first commencement of the present order of nature, we meet, vever, with an abundant Mammalian fauna, containing repre-tatives of nearly all the existing orders, but also including several ordinal types now totally passed away, some of which are of reme interest to the zoologist as connecting together more less completely groups which are now widely separated. In Eocene we are indebted to the palæontologists of the New rld for most of our knowledge of these primitive connecting s; but we can only afford space to notice very briefly some of more interesting groups.

Of Carnivorous types there is a group of Eocene genera known the Creodonta, remarkable, among other features, for their eralised dentition, which has resemblances to that of the Poly-todont Marsupialia and Insectivora, and also to that of the dern Carnivora, of which these forms were probably the ances-s. We thus have indications how the Carnivora of the present may have been gradually evolved from a Marsupial type by ans of forms more or less nearly related to the Insectivora of present epoch. In another direction the Eocene has afforded dence of a transition from the Insectivorous type towards that the Lemuroid Primates, and we may thus readily conceive how higher members of the latter order may likewise trace back ir origin to the same primitive stock.

At the present day no orders of Mammals appear more sharply ined from one another than the Carnivores and the Ungulates. the Eocene, however, we meet with a group of primitive Un-ates, known as the Condylarthra, presenting such remarkable emblances to the primitive Carnivores, that we are led to the clusion that the Ungulates are probably another branch derived from this same prolific stock. From this Condylarthrous subord we have abundant evidence that the two existing suborders of Artiodactyla and Perissodactyla, now so sharply distinguished, ha both taken their origin; and perhaps the Hyracoidea may trace their derivation from this group. Another extinct Eoce suborder of Ungulates, comprising the Coryphodons of Europe a America, and the huge and uncouth Dinocerata of the Uni States, tends to show a connection between the Perissodactyla a Proboscidea, which till recently were referred to distinct orders.

All living Ungulates, as we shall subsequently mention, are d tinguished by the total absence of clavicles, but in the remarkal *Typotherium*, of the Pleistocene of South America, these bones we retained. In its dentition, moreover, that genus shows featur now peculiar to the Rodents; and by its help, together with th evidence afforded by an Eocene group known as the Tillodon we can dimly see how the Rodents may have been connected wi the ancestors of both the Ungulates and the Carnivores.

Having seen from these brief notices how intimate appears t have been the relationship between the chief terrestrial orders o Mammals in the Lower Eocene, we may glance at the evidenc afforded by the Mammals of the Eocene as to the connectio between some of the families of these orders. Among the Car nivora, no two families are better distinguished than the Dogs, or *Canidæ*, with their triangular upper molars and digitigrade feet, and the Bears, or *Ursidæ*, in which the upper molars are rhom- boidal and the feet are plantigrade. In the Eocene, however, we have *Amphicyon*, with the teeth of a Dog and the limbs of a Bear; and in the later Tertiary the Bear-like *Hyænarctus*, of which the dentition retains many Dog-like features. So perfect, indeed, is the transition between Dogs and Bears, that it seems convenient to include both groups in a single family. Again, in another direction, the Dogs of the Eocene seem to pass imperceptibly into the Civets (*Viverridæ*) through *Cynodictis;* while it is almost impossible to distinguish the Civets from the Hyænas on the one hand, and the Cats (*Felidæ*) on the other. Still more remarkable is the apparent connection in the Eocene of the Civets with the Weasels (*Mus- telidæ*), since these two families are widely sundered at the pres- ent day.

Turning to the Ungulates, at the present day the Artiodactylate suborder can be readily divided into four sections—viz., the Pigs, or Suina; the Camels, or Tylopoda; the Chevrotains, or Tragulina; and the Cattle and Deer, or Pecora. When, however, we go back to the early Tertiary, we find a complete transition from the Suina to the Pecora; while it is almost impossible to distinguish Deer from Chevrotains; and the early Camels exhibit signs of close iection with the other families. Similarly, at the same period Pigs of the Old World appear to be inseparable from the caries of the New; while the Giraffes were probably as closely nected with the Antelopes on the one hand, and the Deer on other. Again, in the Perissodactylate suborder Tapir-like forms ear to have passed into Rhinoceroses on the one hand, and into Horses on the other.

Many other equally striking instances could be cited of the tual connection of the Eocene Mammals with one another; but ugh has been stated to show that the present sharply defined tinction of the orders and families into which we find it con-ient to divide the class is, so to speak, but a feature of day.

In the Lower Eocene all the genera of Mammals appear to be inct; but in the Upper division of the same period, which is quently termed the Lower Oligocene, we meet with a few existing iera, such as *Didelphys*, *Rhinoceros*, *Viverra*, *Mustela* (Weasel), l perhaps *Canis*. In the succeeding period, or Miocene, existing iera become more common; thus in the Lower and Middle divi-ns of that period we meet with Otters (*Lutra*), *Rhinoceros*, Tapirs *ipirus*), and Gibbons (*Hylobates*). The middle division of the ocene is, indeed, noteworthy for the appearance of Anthropoid es and the Proboscidea, or Elephants and Mastodons. Deer of inct genera are abundant; but these were either devoid of antlers, if these appendages were present, they were small and simple. e teeth of the Ruminant Ungulates (Deer and Cattle) were, reover, low-crowned or brachydont (fig. 1213), and the Rhino-oses had in most cases not yet developed horns.

With the commencement of the Pliocene period the Mammalian ma assumes a much more modern appearance. Thus we have rcupines (*Hystrix*), Hyænas, large Tiger-like Cats (*Felis*), numer-s Antelopes, Giraffes, Deer (*Cervus*), and Horse-like animals *Tipparion*); while in India true Elephants (*Elephas*) had made eir appearance. There was still, however, a large number of tinct genera. By this time many of the Deer had acquired mplicated antlers; many of the Ruminants had tall-crowned or psodont teeth; the Rhinoceroses had horns; and the Pigs had veloped large tusks in the males. In India during some portion the Pliocene, not only Elephants, but true Horses (*Equus*), ippopotami, Wolves, Bears (*Ursus*), and Oxen (*Bos*) had already ide their appearance; but in Europe these genera are unknown fore the top of the Pliocene, when we first meet with remains of few existing species, such as the African Hippopotamus and the iped Hyæna.

In the succeeding Pleistocene period, which may in reality be regarded merely as the commencement of the epoch in which are now living, the greater number of the Mammals of E belong to existing genera, and a considerable proportion of these living species. The fauna of Europe in the early part of this pe included, however, a large number of Mammals belonging to ge or species now confined to the warmer regions of the globe, as Rhinoceroses, Hippopotami, Elephants, Lions, Hyænas, and it was not till after the great cold of the glacial period these generic types were finally swept away from the Europe area. In many other parts of the World the Pleistocene peri was equally prolific in large forms of Mammalian life, more or l closely allied to those now inhabiting the same areas, of which have remarkable instances in the extinct Edentates of South Ameri and the Marsupials of Australia, many of which vastly exceeded size their living relatives. Science has, indeed, yet to account sat factorily for the disappearance of this exuberant life, and the cons quently impoverished fauna among which we now dwell.

In regard to the Mammals of the Eocene, we have already re marked that they are frequently of a more generalised type than those now existing, and in many groups a well-marked progressive specialisation can be traced as we approach the existing epoch. Thus many of the Eocene Mammals possess the full Eutherian complement of forty-four teeth, which in the Ungulates were more uniform in size, less conspicuously differentiated into groups, and more approximated to one another than in recent forms. In the older Ungulates, moreover, the crowns of the cheek-teeth were relatively short; and we can trace a gradual increase in the height of the crowns as we advance in time, this increase affording a greater capacity to withstand wear, and thus indicating a greater length of life in the individual. In other instances we may observe a gradual reduction in the lateral digits of the typical pentedactylate limb, accompanied by a progressive elongation and strengthening of one or more of the remaining digits. Again, it has been shown that there has been a gradual increase in the relative size and the complexity of the brain as we approach the present day. Thus the Eocene Mammals, as a rule, had very small brains, in which the hemispheres left the cerebellum nearly uncovered, and were themselves nearly smooth, or but slightly convoluted; while in the higher forms the hemispheres spread backwards over the cerebellum, and are often marked by most complex convolutions. In some Eocene Ungulates the brain was so small that it could pass through the neural canal of the lumbar vertebræ.

Finally, it should be observed that we may trace a gradual evolution of local faunas. In the Eocene of any given region we find the Mammals differing widely in generic types from those now in-biting that area, yet as we ascend in the geological scale we trace gradual approximation to the existing fauna; and in the Pleistocene we find the characteristic features of such fauna distinctly marked out, although many of the generic types, especially those including forms of large corporeal bulk, may be different. Examples of these features are afforded by the Marsupials of the Pleistocene of Australia, and the numerous Edentates of the same period in South America; although it is practically certain that in the former case the fauna has always been Marsupial, and therefore more or less closely related to the present one. That many of the existing Mammalian faunas now characteristic of particular regions were not thus circumscribed till a late period is, however, shown by the occurrence of Baboons, Hippopotami, Giraffes, and African types of Antelopes in the Pliocene and Pleistocene of India and parts of Europe; and equally by the Mammals of the Pleistocene of India being in many cases specifically identical with those of Africa, while the number of common species is now very few indeed. Again, many forms like the Rhinoceroses and Horses, which are now exclusively Old World types, formerly wandered over the plains of America, and thus point to a more uniform distribution of types than now exists. There are, however, indications of certain groups of Mammals having always been restricted to one hemisphere. Thus we have no evidence of the existence of Apes, Hyænas, or Civets at any epoch in the New World; and neither are there any traces of the Dinocerata or *Titanotheriidæ* in the Old World.

It was considered probable some years ago that the Mammalia were directly descended from some primitive Amphibian types, and that they stood altogether apart from the Reptiles. The striking resemblance of the pectoral girdle of the oviparous Monotremes to that of many Reptiles, and more especially the Anomodonts, together with the remarkable approximation to a low Mammalian type presented by the skeleton of the latter, renders it, however, more probable that Mammals are a divergent branch of the same Amphibian stock which gave origin to the last-mentioned group, if indeed they be not the direct descendants of the earlier forms of that group. Dr Baur, who considers that Mammals were developed from true Reptiles allied to the primitive Rhynchocephalia and Sauropterygia, has proposed that these early hypothetical forms should be termed Sauromammalia. Professor Mivart has, indeed, suggested that Mammals may have had a dual origin; and that while the Monotremes may have been derived at a comparatively late date from the Anomodonts or kindred types, the Marsupials may have originated at an earlier epoch from a totally distinct and perhaps Amphibian stock. Many objections have, however, been raised against this view; and Mr Poulton expresses his opinion that

"whether the Monotremes are the descendants of the a
Mammalia or not, it is quite certain that the higher Mamma
at one time have passed through a condition such as now
the Monotremes, in nearly all parts of their organisation; an
powerful arguments can be brought against the assumption
same stage has been reached independently, and at widely se
periods, in the course of evolution."[1]

In the following chapters are given the leading palæont
characters of each order of the class, with the range in time
different groups, and the names of the more important gener
number of genera is, however, so great that only a very br
general sketch of their characters and affinities can be given;
attention being drawn, where it may seem necessary, to those
types which are of more than ordinary interest from an evolu
point of view.

[1] The opinion has been recently expressed by some Continental writers
Cetacea are the most archaic type of Mammals, and that they have bee
derived from the Ichthyopterygian Reptiles. There is, however, so m
dence against this view that it may be considered as practically disprove

CHAPTER LIX.

CLASS MAMMALIA—continued.

ORDERS MONOTREMATA AND MARSUPIALIA.

LASS I. PROTOTHERIA.—This subclass, now represented by wo genera, may be characterised as follows. The brain has e anterior commissure, and a very small corpus callosum;[1] the auditory ossicles are simple, and the stapes is rod-like nelliform). The coracoid is a distinct, although small, bone, losing in the adult to the scapula, and articulating with the im; while there is a separate precoracoid (epicoracoid), which not articulate with the scapula, and also a large T-shaped inter-le; the form and relations of these bones being very like those e corresponding parts of the skeleton in the Anomodont Rep- The pelvis has epipubic bones, and the ilia are inclined to acral axis after the Batrachian fashion; thus resembling those e Pariasaurian Anomodonts. The urinogenital and excretory s open into a common outlet, or *cloaca;* and the former are similar to those of the Sauropsida; the mammary glands are ovided with nipples, and the reproduction is oviparous; the being meroblastic like those of Birds.

nay here be observed that the small bone in the pectoral girdle of Monotremes placed in advance of the coracoid, which is usually d the epicoracoid, appears to correspond with the precoracoid of nomodont Reptiles[2] (fig. 978 *bis*, p. 1054), although it does not ex- upwards to articulate with the acromial process of the scapula, as nomodont precoracoid articulates with the process of the scapula ified by Sir R. Owen with the acromion.[3] Further, the scapula of Monotremes differs from that of all other Mammals, and resembles

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he structure connecting the two hemispheres of the brain.
his appears to be the view taken by Professor Cope.
his is the original view. In describing the scapula of *Platypodosaurus*, . Owen confused the process situated above *a* in fig. 978 *bis* with that d *a*, and termed the former the acromion.

that of Reptiles in that the acromion is situated on the anterior or axial border, which in the higher Mammals has become twisted to the dorsal surface to form the spine of the scapula. The scap some of the Anomodont Reptiles appears to indicate how this tor the preaxial axial to form a ridge on the dorsal surface has taken pl

At the close of the preceding chapter reference has been ma the relationship of the Prototheria, or rather of its existing r sentatives the Monotremata, to Reptiles and Amphibia. The ture of the pectoral and pelvic girdles presents, indeed, so striking resemblances to the same parts of the skeleton in Labyrinthodont Amphibia and Anomodont Reptiles, as to indic as already mentioned, a distinct genetic connection between three groups; the characters of the humerus apparently indic

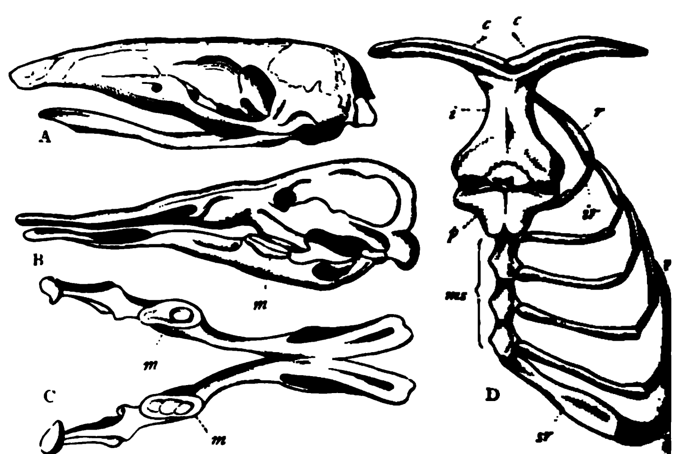


Fig. 1130.—A, Lateral view of skull of *Echidna*; B, Do. of *Ornithorhynchus*: C, Ou mandible of do.; D, Sternal region of do. *c*, Clavicle; *i*, Interclavicle; *p*, Presternum; sternum; *r*, Ribs; *sr*, Sternal ribs; *ir*, Intermediate ribs; *m*, Cornules. Reduced. Flower; the others after Giebel.)

that the nearest relationship is with the Anomodonts. The ciduous teeth of *Ornithorhynchus* indicate, moreover, without doubt that the ancestors of the Monotremes were provided persistent teeth, which were probably monophyodont. M over, a distant resemblance between these deciduous teeth the cheek-teeth of the extinct group, mentioned below under name of Multituberculata, suggests that these forms may thems be Prototheria. If this should prove to be the case, it would be apparent that that branch of the subclass could not have the ancestral stock of the Marsupials; and we shall accord have to look for another group or order of Prototheria, w dentition akin to that of the Polyprotodont Marsupials.

ceed, quite within the bounds of probability that the family -omatheriidæ mentioned under the head of the latter group -y prove to be Prototherians. And in any case it is quite -dent that the two existing genera of Monotremes can in no -y be looked upon as actual ancestral types.

ORDER I. MONOTREMATA.—As already mentioned, both the -sting genera of Prototherians are included in this order, which -y be provisionally characterised by the production of the cranium -o a more or less elongated rostrum supporting a horny beak; by -e absence of teeth in the fully adult animal; the smoothness of -e brain-case; and the absence of an auditory bulla. The humerus -greatly expanded, and has an entepicondylar foramen; its whole -ntour approximating to the corresponding bone of the Anomodont -ptiles (fig. 982).

FAMILY ORNITHORHYNCHIDÆ.—In this family the cerebral hemi- -heres are smooth; the extremity of the muzzle is produced into a

Fig. 1131.—*Ornithorhynchus paradoxus*, Australia. Reduced.

-oad beak-like expansion (fig. 1131); teeth are present in the -ung, and are succeeded by horny plates or cornules (fig. 1130, B, -; and the skin is covered with hair. The feet are webbed. This family is represented solely by the genus *Ornithorhynchus* (fig. of which a single species inhabits the Australian rivers, in the of which its burrows are constructed. According to the o tions of Mr O. Thomas, it appears that there are usually tw on either side of the upper and three in the lower jaw, which till the animal is somewhat more than one-third grown. The have at first small but distinct roots, and present a distant blance to the true molars of some of the Multituberculat *Microlestes;* one of their longitudinal walls, or ridges, carr number of minute cusps. It appears that the cornules grow neath and around these teeth, which are gradually worn awa finally shed like the milk-molars of other Mammals; the holl the cornules being the remnants of the original alveoli.

FAMILY ECHIDNIDÆ.—The second family is characterised convoluted cerebral hemispheres; the production of the muzz a long tube-like beak (fig. 1130, A); the slenderness of the dible; the total absence of teeth; and the presence of stout mingled with the fur. Further, the feet are very strong, and a for digging, and the centre of the acetabulum is imperfectly o There are two living species found in Australia and New G both of which, at least for palæontological purposes, may be in in the genus *Echidna*, although the large *E. Bruijnii*, of New G is frequently separated under the name of *Proechidna*. R of a large species considerably exceeding the latter in size hav obtained from the Pleistocene of New South Wales.

GROUP MULTITUBERCULATA.—In this place it will be conv to notice a group of very imperfectly known Mesozoic and Tertiary Mammals which were formerly regarded as Dipro Marsupials allied to *Thylacoleo*, but which differ in several r from that group, and may perhaps eventually prove to be m of the subclass Prototheria. Although these peculiar for semble the Diprotodonts in having a single pair of lower i like those of Rodents, while many of them also approxim certain members of the same group in having a secant and g fourth premolar; yet they differ in that it is the second in p the first upper incisor which becomes enlarged and oppo the incisor of the lower jaw; while when the fourth lower pr is secant the summit of its crown is extremely convex inst more or less concave. The true molars, as already men appear to approximate in general structure to the deciduous teeth of *Ornithorhynchus*, and are quite unlike those of any Marsupials. Till, however, the structure of the pectoral gi known the serial position of these forms cannot be definitely mined. And it may be observed, that the humerus of th which may be referable to *Tritylodon* is unlike that of the ta, so that if these forms be Prototheria they probably indi- distinct specialised order of that subclass.

addition to the features mentioned above, this group is charac- d by the true molars (fig. 1136) carrying longitudinal rows of cles, separated by one or more grooves, and also by the ab- of a pit or perforation in the masseteric form of the mandible.

MILY PLAGIAULACIDÆ.—In the *Plagiaulacidæ* the premolars, h vary in number from one to four in the mandible (figs. 1132–

1132.—A, Outer view of the right ramus of the mandible of *Plagiaulax minor*; four natural size. B, Fourth lower premolar of *P. Becklesi*; five and a half times natural size. he Purbeck of Dorsetshire. (After Owen.)

), are always of a secant nature, and are usually marked by a s of oblique lateral grooves (fig. 1132); while the true molars mall and reduced to two in number. In the type genus *Pla- lax* of the Purbeck (Upper Jurassic) of Dorsetshire, there may ther four (fig. 1132), or three lower premolars; Professor Cope ding the latter va- n as indicating a ict genus, for which has proposed the *Plioprion*. The r teeth are unknown. *acodon* (fig. 1133), the Upper Jurassic orth America, is a ly allied but per- less specialised type, four lower premo- which are much in the figured speci-

Fig. 1133.—Outer aspect of the right ramus of the mandible of *Ctenacodon serratus*; from the Upper Jurassic of North America. Upper figure, natural size; lower, four times natural size. *a*, Incisor; *b*, Condyle; *c*, Coronoid process. (After Marsh.)

In the upper jaw the anterior premolars are like those of *don*. The figure shows the relatively low position of the con- of the mandible in this family;—a feature shared with the stocene *Thylacoleo*, among the Marsupials. From the Lowest ene, both of France and North America, we have the more ialised genus *Neoplagiaulax* (fig. 1134), in which only the fourth nolar remains in the mandible. The Puerco Eocene of North erica has also yielded *Ptilodus* (fig. 1135), characterised by the presence of a minute third lower premolar. ***Liotomus*** of th Eocene differs from all the others by its smooth fourth I ***Meniscöessus***, from the uppermost or Laramie Cretaceous of th

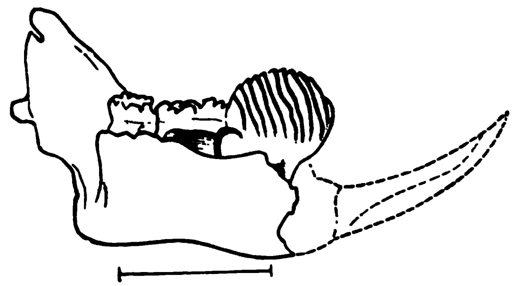


Fig. 1134.—Inner view of the left ramus of the mandible of ***Neoplagiaulax eocaenus*** Lower Eocene of Rheims. The line indicates the true size. (After Lemoin

States, is a somewhat larger form which may probably be in this family. It was first made known by an upper true m secant premolars from the same deposits subsequently under the name of ***Halodon***, with other teeth figured under tl of ***Tripriodon***, ***Diprodion***, and *odon*, are probably all referable *iscöessus*. Another form from mie Cretaceous which may be ally known as ***Cimoliomys***, appe closely allied to the Eocene ***Pti*** may have affinity with ***Plagiau*** teeth described as ***Cimolodon*** a *mys*, as well as one of those re *Halodon* appear inseparable f form. Other generic names h applied to teeth of a more or le allied type from the same depo

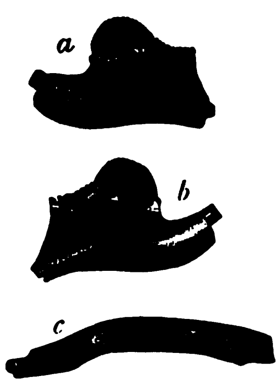


Fig. 1135.—The left ramus of the mandible of *Ptilodus mediaevus*; from the outer (*a*), inner (*b*), and oral (*c*) aspects: from the Puerco Eocene of New Mexico. (After Cope.)

Certain bones from the La scribed as ***Camptomus*** probabl to this group, and are notev showing a distinct coracoid a clavicle; thus, if rightly referred and determined, clearly i the Prototherian affinities of the Multituberculata.

From the Tertiaries of Patagonia Dr Ameghino has certain remains under the generic names of ***Abderites***, ***Aca*** ***Palæotheutes***, which are referred to this family, and are a nearly related to the European genera. The genus ***Microb*** been described from the same deposits, and is regarded as g a distinct family.

.Y POLYMASTODONTIDÆ.—The type genus *Polymastodon* the Lowest Eocene of North America, and has one pre- d two true molars. The premolar is tubercular, and the ie molars have three longitudinal ridges, and are elongated osteriorly.

.Y TRITYLODONTIDÆ.—The genus *Tritylodon* was first de- from a nearly entire cranium found in the Karoo system of frica, in a horizon which is probably of Lower Mesozoic : a tooth (fig. 1136) previously l from the Upper Trias of y, and described under the pied name of *Triglyphus*, o belong to the same genus. er dental formula is *I.* 2, *C.* 0, *M.* 4. The innermost upper s large and scalpriform, while r one is very minute. The rue molars (fig. 1136) carry ngitudinal ridges, and have the iameter of the crown directed sely. The anterior portion of ium is remarkable for its great nd bluntness. The African indicates an animal about the Rabbit. From the same de- t the Cape has been obtained showing the impression of a limb apparently referable to a

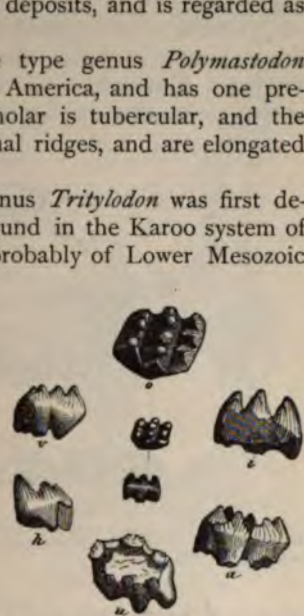


Fig. 1136.—An upper true molar of *Tritylodon Fraasi*; from the Upper Trias of Strasbourg. The two central figures are of the natural size; the others enlarged three times. *o*, Crown surface; *u*, Basal surface; *v*, *h*, The two lateral surfaces; *i*, *a*, Anterior and posterior surfaces. The position of *o* is at right angles to that of the molars in the next figure.

lammal, which has been described under the name of *Ther-* s. If, as is probably the case, this specimen be really lian, there is, however, no reason why it should not belong to *lon*. According to Professor Bardeleben this limb has two in the carpus (as in some Insectivora), and a distinct pre- the alleged fusion of the scaphoid with the lunar being in- To the present family may likewise be referred the very ctly known *Stereognathus*, of the Lower Jurassic of Stones- he upper cheek-teeth of which closely resemble those of *Tri-* Finally, *Chirox*, from the Upper Jurassic of North America, ertain characters connecting the present with the next family, h it is provisionally placed by Professor Osborn.

LY BOLODONTIDÆ.—Nearly allied to the preceding family, the upper true molars antero-posteriorly instead of trans- elongated, and with only two longitudinal ridges, is the genus *Bolodon*, of the Dorsetshire Purbeck. In this genu 1137) there were apparently three upper premolars and fou molars; with probably three incisors, of which the first is minute. Although of much smaller size, the cranium of th species presents a striking resemblance to that of the African ?

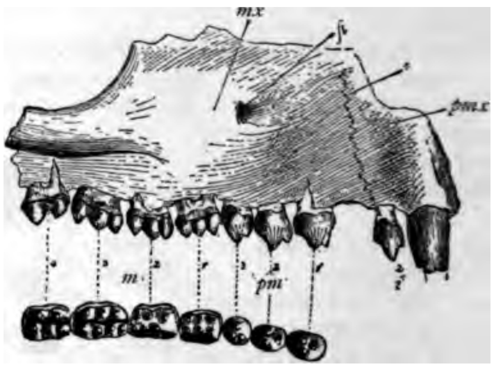


Fig. 1137.—The right maxilla of *Bolodon crassidens*; from the Dorsetshire Purbeck Maxilla; *pmx*, Premaxilla; *fi*, Foramen; *m*, True molars; *pm*, Premolars; *i*, Incisors. enlarged. (After Osborn.)

odon. *Allodon*, from the Upper Jurassic of North America very closely allied, if not identical form, in which there wer tainly three upper incisors, of which the second (fig. 1137) larged, and apparently corresponds to the large inner inci *Tritylodon*. The genus *Microlestes*, from the Upper Trias of temberg and England, is only known tached molars (fig. 1138) closely resen the true molars of *Plagiaulax*. This is referred by Professor Osborn to th *giaulacidæ*: but till it is proved to trenchant premolars it seems preferal place it provisionally in the present f Figure *a* in the accompanying woodcut a side view of the type tooth, which ha rows of tubercles separated by a longit groove; the imperfect crown of another shown in *b*, and provisionally referred to the same genus, is re able for the resemblance presented by its two remaining tub to those of the teeth of *Ornithorhynchus*. The name *Hypsi nopsis* has been applied to a tooth of *Microlestes*, from the E Rhætic.

a *b*

Fig. 1138.—*a*, Lateral view of a tooth of *Microlestes antiquus*; *b*, Part of the crown of a tooth on a still more enlarged scale; from the Upper Trias of Würtemberg. (After Lyell and Falconer.)

SUBCLASS II. METATHERIA.—The members of this subclass with the Prototheria in the structure of the brain and the pre pubic bones[1] (fig. 1139, *m*), but differ in the more specialised ters of the auditory ossicles; in the reduction of the coracoid iere process of the scapula, and its ticulation with the sternum; in the e of an interclavicle; and in the pres- of nipples to the mammary glands. latter characters they agree with the ria, from which they are distinguished presence of an imperfect cloaca, the characters of the urinogenital , which are in some respects inter- te between those of the Eutheria 'rototheria. The young, although ed viviparously, are born in an ex- gly imperfect condition, and are nourished *in utero* by an allantoic ta; but at an early period are trans- to the nipples of the mother, to they adhere for a long time. The s themselves are nearly always con- in a fold of skin forming the so- *marsupium*.

Fig. 1139.—Ventral view of the symphysis and left half of the pelvis of a Kangaroo. *m*, Epi-pubic bones. Reduced.

th are invariably present, and are le into the usual four groups. With the exception of the *olomyidæ*, the number of incisors in the upper jaw of all exist- rms exceeds that in the mandible.[2] The true molars are very lly four in number on either side of each jaw; and in all g forms the number of premolars does not exceed three, gh four (which may be taken as the typical number) are in several Mesozoic genera. The most remarkable feature the dentition is, however, that it is only the last premolar (the of the typical series) among the whole number of teeth that as a milk predecessor; such predecessor generally resembling ue molars in structure. Some genera, like *Phascolomys*, show, er, no signs of even this single replacement; and it is pretty that we have here the first commencement of a replacing series th, which in the early Eutheria must have gradually extended orly, until it normally embraced all the teeth in advance of , with the very general exception of *Pm.* 1, although in certain odactyla even that tooth had a milk predecessor.

other very characteristic, although not universal, feature in this ss is the inflection of the angle of the mandible (fig. 1152);

[1] ossified in *Thylacinus*.
[2] e same feature occurs among the Anomodont Reptiles in the *Galesauridæ*.

and in many genera the palatal region of the cranium cc unossified vacuities of considerable size.

ORDER II. MARSUPIALIA.—The whole of the known Met are included in the single order Marsupialia, and it is not at p necessary to give ordinal characters as distinct from those subclass. At the present day this order is restricted to A and the Australian region; the greater number of forms occ in the latter area, while only the *Didelphyidæ* are found in the f In earlier epochs, however, this order was much more wide tributed, and it apparently contains some of the earliest l representatives of the entire class.

Marsupials form in some respects the intermediate stage be the Prototheria and Eutheria, and it is probable that there w eventually found a complete transition from the Polyprotodon order of this group to unknown Prototherian Mammals wit same general type of dentition—possibly more or less closely to the undermentioned Triassic family *Dromatheriidæ*.

SUBORDER I. POLYPROTODONTIA. — In existing Polyprot Marsupials, which occur both in America and the Australian r there are never fewer than three lower and four upper incisor there may be five upper and four lower teeth of this series. ' teeth are small and subequal, and are followed by a larger c (fig. 1148). Normally there are three premolars, correspondi the first, third, and fourth of the typical series, but the fourth be absent, *Dasyurus* and *Sarcophilus* (fig. 1148). The numl true molars is generally four, but in *Myrmecobius* these teet increased to $\frac{5}{6}$; and their crowns are nearly always characteris carrying a number of small, sharply pointed cusps. In no sp is there a fourth premolar of the elongated secant form charact of many Diprotodonts. Several of the Mesozoic forms included i group agree very closely with the recent ones, but many of them four premolars, and in some there are as many as seven true m

FAMILY DROMATHERIIDÆ.—This family, typically represent the genus *Dromatherium* (fig. 1140), of the reputed Trias of N America, is provisionally p here, since it may be relat some of the members of the family, although Professor O makes it the type of a di order — the Protodonta — even suggests that it ma Reptilian. If not Marsu these early Mammals may prove to be representatives of a gro Prototheria from which the Polyprotodont Marsupials have o

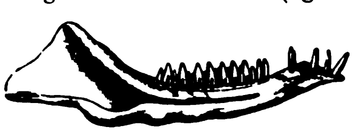


Fig. 1140.—Inner view of the left ramus of the mandible of *Dromatherium sylvestre*; from the Trias of North Carolina. (After Emmons.)

ated. The cheek-teeth differ from those of all other Marsupials in having the fangs imperfectly divided, and thus approximate to those of certain Anomodont Reptiles. There are seven true molars, the incisors are spaced, there is long diastema behind the canine, and the three premolars are of a very simple structure. The crowns of the true molars consist of one main cusp, with small accessory cusps; and it would appear that the teeth of the upper and lower jaws mutually interlocked. This type of tooth is regarded by Professor Osborn as the most archaic yet known. *Microconodon*, which occurs in the same deposits as *Dromatherium*, is an allied but smaller form.

FAMILY AMPHITHERIIDÆ.—This Mesozoic family is provisionally taken to include a number of small and imperfectly known forms, some of which are regarded by almost all writers as undoubtedly Marsupials, although others have been referred by Professor Osborn, with some hesitation, to the Insectivora, under the name of Insectivora Primitiva; those which are retained by that writer in the present order being termed Prodidelphia. Although it is quite probable that with fuller information the two sections into which this family is divided may be raised to the rank of separate families, yet the evidence brought forward by the writer mentioned above in favour of referring some of the genera to the Insectivora appears to be insufficient; no members of that order having more than three lower incisors or more than the normal three molars of the other Placental Mammals.[1] Considerable confusion has arisen in regard to the dentition of many of the members included in this family owing to the circumstance that in the mandible only one side of the teeth is generally seen, so that several genera have been made upon the evidence of remains of a few closely allied species. The clearing up of this confusion is mainly due to the careful observations of Professor Osborn. In this family all the genera are characterised by a channel on the inner side of the mandibular rami known as the *Mylohyoid groove* (fig. 1147)—a feature occurring in many recent Polyprotodonts. The number of lower incisors was probably always four (as in the modern *Didelphyidæ*), and the lower true molars are frequently in excess of that number, as in *Myrmecobius* alone among existing heterodont Mammals. These true molars may either consist of three or more cusps arranged in a single line, or they may be differentiated into a tritubercular blade followed by a posterior heel or talon. The premolars are very generally four in number, but they may be reduced to three, or perhaps two. Not unfrequently, as in the existing *Peramelidæ*, the root of the canine may be grooved.

[1] Judging from his latest memoir on the subject, it is probable that Professor Osborn would now considerably modify his views as to these divisions.

As a provisional measure this family may be divided into two groups or subfamilies, of which the first may be eventually raised to the rank of a distinct family. The first subfamily, or *Phascolotheriinæ*, is referred by Professor Osborn to his Prodidelphia, and is included in the *Triconodontidæ* (*infra*). The lower true molars consist typically of three main cusps arranged in a line, together

Fig. 1141.—Inner view of the right ramus of the mandible of *Phascolotherium Bucklandi*; from the Stonesfield Slate. Twice natural size. The outline figure is natural size. There should be a fourth incisor. (After Owen.)

with some accessory cusps; and it would appear that the upper molars were of similar structure. The lower incisors are separated from one another by intervals. The typical genus *Phascolotherium* (fig. 1141), from the Lower Jurassic slate of Stonesfield, in Oxfordshire, has the condyle of the mandible placed very low down; the lower dental formula is *I.* 4, *C.* 1, *Pm.* + *M.* 7, the canine is separated by a diastema from the first premolar, and the true molars have a well-marked cingulum on the inner side. *Amphilestes* (fig.

Fig. 1142.—Reversed inner view of the left ramus of the mandible of *Amphilestes Broderipi*; from the Stonesfield Slate. Twice natural size. The restoration of the anterior teeth is conjectural; and the condyle is placed too high. (After Owen.)

1142), from the same deposits, has a more numerous series of cheek-teeth, and a higher mandibular condyle. The exact dental formula is not known, although it may have been the same as in the undermentioned *Amblotherium*. The mandible from the same beds shown in fig. 1143 has been made the type of the genus *Amphitylus;* and according to Professor Osborn has teeth of the e general type as those of the preceding genera. If this be it would appear to countenance the view that the present group ould be separated from the *Amphitheriidæ*, but owing to the amaged condition of the specimen great caution is necessary n speaking positively as to the ature of the teeth.

Fig. 1143.—Outer aspect of the right ramus of the mandible of *Amphitylus Oweni*; from the Stonesfield Slate. Enlarged. (After Owen.)

In the second subfamily, or *Amphitheriinæ*, the lower true molars are differentiated into a ritubercular anterior blade and posterior heel or talon. Four remolars are present in all those genera of which the entire lower entition is known; and the mandibular condyle is high. The pper molars are unlike the lower. Many of these genera are ferred by Professor Osborn to his Insectivora Primitiva.

Before proceeding further some explanation is necessary as to e structure of this type of lower molar. Following the nomen-

Fig. 1144.—Outer aspect of the left ramus of the mandible of *Dryolestes vorax*; from the per Jurassic of North America. Three times natural size. *a*, Canine; *c*, Coronoid process; Angle. The incisors and first premolar are absent. (After Marsh.)

ature adopted by Professor Flower the three cusps in the anterior alf of such a "tritubercular" tooth may be collectively spoken of the *blade* (fig. 1145, *a*, *b*, *c*); while the hinder part (*d*) may be rmed the talon. In the blade the cusp *a* is termed the anterior,

Fig. 1145.—Upper, outer, and inner views of a left lower true molar of *Dasyurus*. *a*, Anterior usp of blade (*paraconid*); *b*, Posterior cusp of do. (*protoconid*); *c*, Inner cusp of do. (*metaconid*); *d*, Talon (*hypoconid*).

he large one *b* the posterior, and the small one *c*, which is the nnermost, the inner cusp. According to Professor Osborn these hree cusps correspond to the three cusps of *Priacodon* (fig. 1147), nd in both cases he applies to them the names of *para-*, *proto-*,

and *metaconid;* calling the talon of the present type the *hyp*
Corresponding terms ending in *cone* are applied to the upper
of the same types.

It will be obvious that when a jaw is embedded in matrix
the inner surface exposed we shall only see the cusps *a* and
the talon *d;* while when the outer surface is visible only the
cusp *b* will be observed. An example of the latter occurren
shown in fig. 1146; and this circumstance has been the fr
source of error in regard to a number of the Mesozoic types
consideration.

In the type genus *Amphitherium* of the Stonesfield Slat
Lower Jurassic, the exact dental formula is unknown, but it
perhaps have been the same as in the next genus.[1] In *A*
therium (= *Peraspalax*, *Phascolestes*) of the Purbeck, or U
Jurassic, of Dorsetshire, the lower dental formula is *I.* 4,

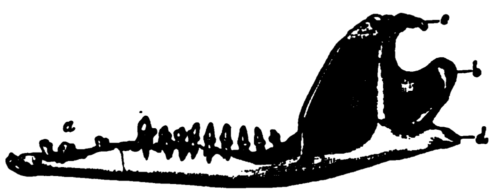


Fig. 1146.—Outer view of the left ramus of the mandible of *Amblotherium gracile;* Upper Jurassic of North America. Three times natural size. *a*, Canine; *c*, Coronoid *b*, Condyle; *d*, Mandible. (After Marsh.)

Pm. 4, *M.* (7–8), or the same as in the American Jurassic
lestes (fig. 1144). Several species are known, in some of
there were seven, and in others eight lower molars. The
Stylodon has been founded upon the outer side of mandil
Amblotherium, in which only the large posterior cusp (protc
of the blade of the molars is visible, as in the lower jaw sh
the accompanying woodcut, which has been made the type
genus *Stylacodon*, of the Upper Jurassic of North America.
latter has eight lower molars, while the English form ha
seven. *Achyrodon*, of the English Purbeck, is closely all
Amblotherium, but differs in the form of the cusps of the
Peramus (*Leptocladus*) is a third Purbeck genus, with rel
stouter lower molars, in which Professor Osborn gives the
dental formula as *I.* 3, *C.* 1, *Pm.* 6, *M.* 3. The North Am
Dryolestes has relatively shorter lower molars (fig. 1144), the
cut clearly showing the three cusps of the blade and the t
these teeth. *Asthenodon* and *Laodon* are other North Am

[1] Professor Osborn regards it as *I.* ?, *C.* 1, *Pm.* 5, *M.* 6.

aracterised by the small size of the talon of the lower while the names *Dicrocynodon* (*Diplocynodon*), *Docodon*, *eodon*[1] have been applied to more or less closely allied om the same deposits. Finally, Professor Osborn has name *Kurtodon* to certain upper jaws from the English which are probably referable to one or other of the above-d genera. From the Laramie Cretaceous of North America Marsh has described the remains of allied types. One of been termed *Didelphops* (*Didelophodon* or *Cimolestes*), while has been referred to the Jurassic genus *Dryolestes*, and as been made the type of the genus *Pediomys*. The re-e in the structure of the lower molars of the *Amphitheriinæ* the corresponding teeth of *Dasyurus* and the *Didelphyidæ*, hat the latter have originated from an allied stock.

SPALACOTHERIIDÆ.—The genus *Spalacotherium*, with *ralestes* is identical, has a dentition which may probably ssed by the formula $I. \frac{?}{3}, C. \frac{1}{1}, Pm. \frac{4}{4}, M. \frac{6}{6}$. The rs consist of a single column carrying three cusps, and sponding to the blade of the tooth of the *Amphitheriinæ*. ction in the number of the lower incisors distinguishes ly from the last; but it is difficult to say whether the f the talon in the lower true molars is or is not a more d feature. The molars, which are of the typical trituber-e, approximate very closely in their plan of structure to the genus *Chrysochloris* among the Insectivora, but this taken as indicative that the present genus should be o that order, since a precisely analogous resemblance ex-en the molars of *Tupaia* in the Insectivora and *Perameles* rsupials. *Menacodon*, from the Upper Jurassic of North is an allied genus.

TRICONODONTIDÆ.—The last family of Mesozoic Mam-have to consider is represented by the English Purbeck *riconodon* (*Triacanthodon*), and the allied or identical (fig. 1147) of the Upper Jurassic of North America. Osborn includes in this family the *Phascolotheriinæ* entioned; but the reduction in the number of the in-l the general *facies* of the teeth seems to indicate con-difference—although the two groups are probably more early related. The mandibular condyle is placed still n in *Phascolotherium*, and apparently, indeed, than in known Mammal. The upper cheek-teeth resemble the he dental formula in the mandible is *I.* 3, *C.* 1, *Pm.* 4, The incisors were approximated, the cheek-teeth have

[1] Preoccupied, see page 1015.

an inner cingulum, and the molars consist of three subequal c or cusps of a trenchant form, arranged longitudinally. There apparently either three or four molars in different individuals single species. The fourth premolar was preceded by a milk- resembling the true molars. It was considered by Sir R. O that the lower true molars of this genus corresponded to those the existing *Thylacinus*, in which there is a bilobed blade and talon. According, however, to Professor Osborn, this interpretati is incorrect; and that observer considers that the three cusps of t

Fig. 1147.—Inner view of the left ramus of the mandible of *Priacodon ferox*; from the U Jurassic of North America. Three times natural size. *c*, Coronoid; *g*, Mylohyoid groo Symphysis. The anterior teeth are wanting. (After Marsh.)

Triconodont type represent the three main cusps of the tooth *Phascolotherium* (fig. 1141), and also correspond to the three lo of the blade of the tritubercular molar of the *Amphitherium* t (fig. 1145); and he accordingly terms these three cusps the *pa proto-*, and *metaconid*, and considers that the talon (*hypoconid*) unrepresented.

FAMILY DASYURIDÆ.—With this family we come to the consid tion of the existing Marsupials. The *Dasyuridæ* is an exclusi Australian family, comprising the largest known members of suborder, and is divided into the subfamilies *Dasyurinæ* *Myrmecobiinæ*. These are always *I.* $\frac{4}{3}$, *C.* $\frac{1}{1}$; but the numbe cheek-teeth varies, although there are never more than three molars. In the pes the hallux is usually either rudimental absent, but the other four digits are well developed and subequal. the *Dasyurinæ* the number of cheek-teeth does not exceed $\frac{7}{7}$, upper true molars have triangular crowns, and those of the lo molars are differentiated into an anterior blade and a posterior ta (fig. 1145), like the lower carnassial tooth of many of the place Carnivora of the present day. The mylohyoid groove may present both in this and the next subfamily. The Tasman Wolf is the sole living representative of the genus *Thylacinus* h the cheek-teeth number *Pm.* $\frac{3}{3}$, *M.* $\frac{4}{4}$, and the humerus has ramen; but in the Pleistocene of Australia there occurs the iderably larger *T. spelæus*. *Sarcophilus*, of which the dentition own in fig. 1148, is also confined at the present day to Tas-

Fig. 1148.—Left lateral view of the dentition of *Sarcophilus ursinus*. Recent, Tasmania. *i*, Incisors; *c*, Canine; *pm*, Premolars; *m*, Molars. The tooth marked *pm* 2 is really *pm* 3.

mania, but a larger species inhabited the mainland of Australia in the Pleistocene. Indications of specialisation are shown by the reduction of the premolars to two, and also by the loss of the foramen in the humerus. The most generalised genus of the subfamily is *Dasyurus*, comprising several species of smaller size than the preceding. In the lower molars (fig. 1145) the blade has three cusps arranged in a triangle, and thus differs from those of *Thylacinus*, in

Fig. 1149.—*Myrmecobius fasciatus*, Australia. Reduced.

which the inner cusp is wanting. There is a mylohyoid groove in the mandible, and the humerus has a foramen. Species of *Dasyurus* at the present day range over the whole of the Australian continent, one of them dating from the Pleistocene. The subfamily *Myrmeco-*

biinæ is represented solely by the genus *Myrmecobius*. In th[e re]markable animal (fig. 1149) the lower incisors are separated [from] one another, the cheek-teeth number $\frac{8}{9}$, of which the first th[ree in] either jaw are premolars; while the molars have quadrangular [multi]cuspidate crowns, and are not well differentiated from the prem[olars.] Although some writers doubt the connection, it is probable [that] *Myrmecobius* is the direct descendant of forms closely allie[d to] *Amphilestes*, of the Lower Jurassic of England; the relations of [the] two being perhaps somewhat similar to that existing between [the] living *Sphenodon* of New Zealand, and the more specialised *Hyp[er]odapedon* of the English Trias.

FAMILY PERAMELIDÆ.—In this family, comprising the Bandicoo[ts] of Australia and New Guinea, the dental formula is *I.* $\frac{(4-5)}{3}$, *C.* ..., *Pm.* $\frac{3}{3}$, *M.* $\frac{4}{4}$, and the pes has two of the digits reduced and con[]nected by integument, as in the *Macropodidæ* among the Dipro[to]donts. Occasionally the canines have grooved or double roo[ts.] Remains of existing species of *Perameles* and *Peragale* occur in th[e] Pleistocene of New South Wales.

FAMILY DIDELPHYIDÆ.—In all the members of this family th[e] dental formula is *I.* $\frac{5}{4}$, *C.* $\frac{1}{1}$, *Pm.* $\frac{3}{3}$, *M.* $\frac{4}{4}$. The incisors are ve[ry] small and sharp; the canines are large; the premolars compressed; and the true molars constructed on the general plan of those of

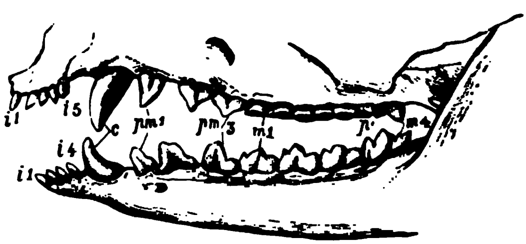


Fig. 1150.—Left lateral view of the dentition of *Didelphys Azaræ*; South America. *i*, Incisors; *c*, Canine; *pm*, Premolars; *m*, True molars. The teeth marked *pm* 3 should be *pm* 4; the teeth between these and *pm* 1 being *pm* 2.

Dasyurus; the lower ones having a blade and talon, with a distinct inner cusp to the former. Each foot is furnished with five complete digits; and the humerus has an entepicondylar foramen. At the present day the Opossums, as the members of this family are commonly called, are confined to the New World, where they are represented by the genera *Didelphys* (fig. 1150) and *Chironectes*;

tter being known only by a single species. Remains of exist- pecies of both genera occur very commonly in the Pleistocene ias of the Brazilian caves; and to the type genus may also be ed a large number of species from the Lower Miocene and r Eocene of Europe, which by some writers are referred to ct genera under the names of *Peratherium* and *Amphipera-* im. *Spalacodon*, of the Eocene of Hordwell, is probably a *phys*. It was in *Didelphys Cuvieri*, of the Paris gypsum, that

1151.—*Didelphys* (?) *fugax*; from the White-river Miocene of Colorado. Twice natural , *b*, Inferior and lateral views of skull; *c*, *d*, Superior and lateral views of right man- ramus. (After Cope.)

er demonstrated the existence of marsupial bones by a careful ing of the matrix. Other extinct forms from the Miocene of h America (fig. 1151) may in all probability be referred to the genus.

BORDER 2. DIPROTODONTIA.—If we exclude the Multituber- a, which have been already mentioned, this suborder will be ned to the Australian region, where it has been known since Pleistocene; and with this limitation it may probably be re- ed as an offset from the more generalised Polyprotodontia. In ses there is only a single pair of lower incisors, but in the upper there are usually three pairs of such teeth, although they are ced to one in the Wombats. lower incisors, and the first, nermost, pair of upper in- s are always of large size and ted for cutting. The canines requently absent, and when nt are of relatively small size. crowns of the true molars either tuberculate or have verse ridges; and as a general there are not more than two olars. Very frequently the last premolar has a long and narrow n, with a concave superior border adapted solely for cutting.

Fig. 1152.—Posterior reduced view of the mandible of the Wombat (*Phascolomys*).

FAMILY PHASCOLOMYIDÆ.—This family is now represented only by the genus *Phascolomys*, or Wombats; in which the dental formula is $I.\ \frac{1}{1},\ C.\ \frac{0}{0},\ Pm.\ \frac{1}{1},\ M.\ \frac{4}{4}$, and all the teeth grow from persistent pulps. The true molars have curved crowns consisting of two subequal lobes, while the premolar has only a single lobe, and is not preceded by a milk-tooth. The mandible (figs. 1152, 1153) is characterised by having a pit and perforation in the masseteric fossa. The fore and hind limbs are of equal length, the former being of great strength in accordance with the fossorial habits of the genus; and the humerus has a foramen. There are five digits in the manus, all of which are provided with long curved claws, and are of subequal size; but in the pes the hallux is imperfect, and the three middle digits are of nearly equal size, and partly enclosed in a common integument. Three existing species of Wombat are known, which are divided into two groups according to the char-

Fig. 1153.—Left lateral view of skull of Wombat (*Phascolomys latifrons*). Reduced. Australia.

acters of the skull and teeth; none of them being of large size. In the Pleistocene of Australia we meet with remains not only of these existing species, but also with several extinct types, one of which was of considerably larger dimensions. In the same deposits are also found remains of the extinct genus *Phascolonus* (with which the so-called *Sceparnodon* appears to be identical), characterised by certain peculiarities in the incisors. The one known species probably attained the dimensions of a Tapir, although of considerably stouter build.

FAMILY NOTOTHERIIDÆ.—This family is represented only by a single definitely known genus from the Australian Pleistocene described as *Nototherium*.[1] This includes one (or possibly more) large

[1] It has recently been suggested that the figured skull does not belong to *Nototherium*, and that it should be termed *Zygomaturus*; but this view is not sup-

and appears to have been allied in many respects to the ts, although presenting several of the dental characters of the mily. The dental formula is *I.* $\frac{3}{1}$, *C.* $\frac{0}{0}$, *Pm.* $\frac{1}{1}$, *M.* $\frac{4}{4}$; and ars that, at least normally, there was no deciduous milk- The cheek-teeth are rooted; the crowns of the true molars g two simple transverse ridges. The cranium (fig. 1154) ts a very singular contour, the nasals being transversely ex- d; and the mandible differs from that of the *Phascolomyidæ*

. 1154.—Left lateral view of the skull of *Nototherium Mitchelli*; from the Pleistocene of Australia. One-sixth natural size. (After Owen.)

he absence of a pit or perforation in the masseteric fossa (fig.). The limb-bones appear, however, to have resembled those he latter family; the humerus having a distal foramen, and g evidently adapted for fossorial habits, although it is difficult elieve that an animal of such comparatively large bulk could lived in burrows.

MILY DIPROTODONTIDÆ.—The genus *Diprotodon*, of the Aus- n Pleistocene, is the sole representative of this extinct family, the type species (fig. 1155) is the largest known member of rder; its bulk being fully equal to that of a large *Rhinoceros*. dental formula is the same as that of *Nototherium*; and the ture of the cheek-teeth of the two genera is also very similar, ugh the lower true molars of *Diprotodon* have no median tudinal bridge. In the incisors of this genus the first pair are

by sufficient evidence. A small Nototheroid from Queensland has re- the preoccupied name *Owenia*.

scalpriform, and grow from persistent pulps. The fore and limbs are of approximately equal length, and adapted sole walking; the humerus has no foramen; and it is probable th covering of the toes approximated to the nature of hoofs. mandible, although more convex below, is not unlike that of *therium*. Professor Huxley has named a second species o

Fig. 1155.—Left lateral view of the skull of *Diprotodon Australis*; from the Pleis of Australia. Much reduced. (After Owen.)

evidence of premolars, but it is not certain that this determi is correct.

Family Phalangeridæ. — This family includes the e Phalangers and the Koala (*Phascolarctus*), as well as a rema extinct genus. All these animals have $I. \frac{3}{1}$, and an upper a quently also a minute lower canine; while the premolars m from $\frac{2}{1}$ to $\frac{3}{3}$, and the true molars from $\frac{1}{2}$ to $\frac{4}{4}$. The struct the cheek-teeth is subject to great variation in the different g the fourth premolar being either secant or tubercular. Ther pit or perforation in the masseteric fossæ of the mandible. limbs are of nearly equal length; the manus has five subequal but the second and third digits of the pes are very slend partially united by integument; and the hallux is always opp In many of the true Phalangers the fourth premolar is groove the dentition closely resembles that of the existing genus *prymnodon* among the *Macropodidæ*. Of living genera the o o occur in a fossil state is *Pseudochirus*, of which the remains isting species are found in the Pleistocene cave-deposits of uth Wales. The most interesting member of the family is, t, the large Pleistocene *Thylacoleo* (fig. 1156), which forms e of a distinct subfamily. The dentition may be represented formula $I. \frac{3}{1}$, $C. \frac{1}{0}$, $Pm. \frac{3}{3}$, $M. \frac{1}{2}$. The true molars and premolars were small, and more or less functionless, while urth premolar is enormously developed, and has a long sharp g-edge, so that, in union with its fellow of the opposing jaw,

. 1156.—Right lateral view of the skull of *Thylacoleo carnifex*; from the Pleistocene of Australia. One-fifth natural size.

ms a cutting instrument of extraordinary power. In originally ibing this remarkable animal from fragments of jaws containing ourth premolar, Sir Richard Owen came to the conclusion that tructure of this tooth indicated a carnivorous animal adapted ey upon the huge Diprotodons and Nototheres; but the dis-y of the complete skull has shown that the animal was more ly allied to the existing Phalangers, and that it could not have ssed the destructive habits attributed to it by its describer, ugh it is quite probable that its diet may have included the er mammals, birds, and eggs. It was at one time considered the Multituberculata were allied to this genus.

AMILY MACROPODIDÆ.—The last, and in many respects the specialised family of the Diprotodontia includes the Kan-s, Wallabies, and Kangaroo-rats. The dentition is represented he formula $I. \frac{3}{1}$, $C. \frac{(0-1)}{0}$, $Pm. \frac{2}{2}$, $M. \frac{4}{4}$. The incisors are mely secant, those of the mandible being frequently movable st one another. The premolars may have either triangular or ng crowns, and in the latter case (fig. 1158) are frequently ed; the third premolar is always, and the fourth in some cases, deciduous, the latter being invariably preceded by a milk-too true molars have either four tubercles or two transverse rid frequently an anterior talon. The mandible has a deep pit foration in the masseteric fossa. The pectoral limb is alw or less markedly shorter than the pelvic. The manus is with five subequal digits; but in the pes (fig. 1157) the generally absent, the second and third digi very minute and enclosed in a common int (*syndactylous*), while the fourth is greatly enlar forms the main base of support. The ma forms progress by making enormous leaps b of their powerful hind-limbs; but a few, like *lagus* of New Guinea, are arboreal. This fan be divided into three subfamilies. In the *Hypsiprymnodontinæ*, there is a distinct hall the dentition closely resembles that of the *gerida;* the fourth premolar being small, grooved, and directed inwardly at its anterio In the small existing *Hypsiprymnodon* there is between the lower incisor and the fourth p but in a large extinct form from the Pleist New South Wales, described under the nam *clis*, there is a minute tooth behind the lowe corresponding to the tooth in the *Phalanger* monly reckoned as the representative of the This genus, therefore, forms an important link the last-named and the present family. In th subfamily, or *Potoroinæ*, the hallux is abs first upper incisor is narrower and longer than the others (fig. 1158); there is always an u

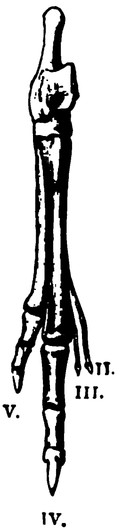


Fig. 1157.— Dorsal aspect of the right pes of *Macropus Bennetti*. Reduced. (After Flower.)

ine; the fourth upper premolar is elongated and secant, an with the grooves strongly marked; while the true molars a culate, with the fourth smaller than the third. The Kang are divided into the genera *Potorous* (*Hypsiprymnus*), *L* and *Æpyprymnus;* the latter being represented in the Pl of New South Wales by remains of the existing species.

The third subfamily, or *Macropinæ*, is distinguished fron by the following characters: The cutting-edges of the uppe form nearly a straight line (fig. 1159); the upper canine i either absent or very small; and the fourth premolar, which shorter or longer than the first true molar, has either an in ridge or lobe. In the existing genus *Macropus* (Kangar fourth upper premolar has a sharp cutting outer edge, and ridge or tubercle; and this tooth in both jaws may be eith or shorter than the first true molar. The two rami of the not anchylosed together, and the hind-limbs are much longer n the front ones. A large number of fossil species occur in the stralian Pleistocene, among which may be mentioned several y large forms like *M. brehus*, which have the fourth premolar ger than the first true molar, and are allied to the small existing llaby, *M. ualabatus* (which also occurs in the Pleistocene).

Fig. 1158.—Dentition of *Potorous*. *i*, Incisors; *c*, Canine; *pm*, Premolar; *m*, Molars.

Then, again, we have in the same deposits remains of the existing Rock-Kangaroo, *M.* (*Petrogale*) *penicillatus*, and also of the larger *M. robustus*, and some allied extinct forms. Another group, in which the fourth premolar is very small and soon falls out, is represented by the existing *M. giganteus*, and the larger extinct *M. titan* and *M. ferragus*. *Sthenurus* is an entirely extinct genus characterised by the presence of a distinct inner lobe to the fourth upper premolar, and is represented by a single species of considerable size. In *Procoptodon*, again, which is likewise extinct, the fourth

Fig. 1159.—*Macropus Bennetti*. Lateral view of skull; from Australia. Reduced.

upper premolar is like that of *Sthenurus*, but the rami of the mandible become anchylosed together in the adult; more than one species are known. Finally, the extinct *Palorchestes*, comprising he largest known member of the family, is distinguished from the ast-named genus by the longer mandibular symphysis, and the bsence of an anterior talon in the upper true molars. The length

of the skull of the one known species is estimated at as m
sixteen inches.

Of Uncertain Ordinal Position.—Here may be conveniently n
some minute Mammals, mostly known by teeth or fragme
jaws, from the Lowest Eocene of Rheims, of which it is diffi
say whether they are Marsupial or Placental, although it is
probable that some of them belong to the former division. A
these may be mentioned *Tricuspodon*, with teeth resembling
of *Spalacotherium*; the allied *Orthaspidotherium* and *Pleur*
therium; and *Procynictis*, in which the true molars approxim
those of *Amblotherium*.

CHAPTER LX.

CLASS MAMMALIA—continued.

ORDERS EDENTATA, CETACEA, AND SIRENIA.

SUBCLASS II. EUTHERIA.—The whole of the remaining orders of Mammalia are grouped together in a single subclass,[1] which is characterised by the fœtus being nourished *in utero* by means of the maternal blood passing through an allantoic placenta. This subclass is sometimes termed the Placentalia, but more generally the Eutheria. Throughout this subclass the urinogenital organs are provided with an external aperture quite distinct from that of the alimentary tube; the corpus callosum of the brain is well developed; there is never any marked inflection of the angle of the mandible; and distinct epipubic bones are absent in the pelvis. With the exception of the three orders forming the subject of the present chapter, the dental formula can always be reduced to some modification of that given on page 1249. At the present day the various orders have become so well differentiated as to render their definition comparatively easy; but fossil forms indicate such a close connection between the majority of them, that such definition becomes frequently a matter of extreme difficulty, if not an absolute impossibility; and it is to be remembered that it is entirely due to our non-acquaintance with forms which must have once existed that renders even these imperfect definitions practicable.

There is at present no conclusive evidence of the existence of any member of this subclass previous to the Eocene.

ORDER III. EDENTATA.—The Edentata are widely different from all other existing Mammals, although there are indications of affinity to certain extinct forms mentioned in the sequel under the heading of the Tillodontia. Almost the only common character presented by the various existing members of this order is that the teeth, when

[1] It has, indeed, been proposed to form a separate subclass—Paratheria—for the reception of the Edentates.

present, are devoid of enamel, are never developed at the extr ties of the jaws in the situation of the incisors of other Mamı and are always homœodont and grow from persistent pulps; with the exception of one genus of the *Dasypodidæ*, they are wise monophyodont. It has, however, been recently observe Dr Ameghino that enamel was present in the teeth of certain S American fossil forms; while in the genus *Diadomus*, from deposits, a pair of canine-like teeth occur in the symphysis c mandible. In many of the genera the teeth are simply cylinc but they may be transversely ridged, and occasionally they have complex internal structure. Not unfrequently the maxillary sends down a large descending process in the zygomatic arc 1163 *bis*); and certain members of the order are remarkable as the only known Mammals which develop a bony exoskeleton. cervical vertebræ are short and wide, with nearly flat terminal to their centra.

The distribution of the Edentates is very restricted. In E neither at the present day nor in past times is there any kno presentative of the order; the so-called *Macrotherium* bein known to be identical with the Ungulate genus *Chalicotherium*, *Ancylotherium* is also allied to the latter. In tropical Asia w the Pangolins or *Manidæ;* and in Africa the *Orycteropodidæ*. America is, however, the headquarters of the order, which is represented at the present day by the Anteaters, the Sloths, a Armadillos, and in past epochs by the huge Ground-Sloths a Glyptodonts. The gigantic size of these fossil forms as com with their existing allies of the same area is paralleled by t stance of the fossil Diprotodont Marsupials of Australia.

It is evident that the Edentates are widely separated fro other existing Eutherians; and Professor W. K. Parker, in v the tendency to a variation in the number of cervical vertebr other features, has suggested a separate origin from a Prototl stock. Professor Cope, however, looks upon the order as all the Tillodonts, and the occurrence of enamel in the teeth of fossil forms may support this view.

FAMILY ORYCTEROPODIDÆ.—The Ant-Bears (*Orycteropu* Africa are characterised by the body being covered merely few hairs; and by the numerous teeth, which are of a rema complex structure, owing to the presence of a number of v pulp-canals. In the fore-limb the pollex is absent, but the limb has five digits. The femur has a third trochanter, an terminal digits are provided with moderate-sized claws, suital digging the burrows in which these creatures dwell. At the p day *Orycteropus* is mainly characteristic of the Ethiopian r although one of the two species ranges into Egypt. Till v ently nothing was known of the palæontological history of the family, but Dr Forsyth-Major has recorded a species from the Lower Miocene of the isle of Samos, in the Turkish Archipelago, distinguished from the existing species by the larger size of the lateral

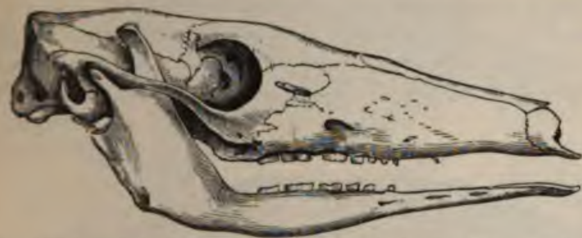


Fig. 1160.—Lateral view of the skull of *Orycteropus capensis*. Africa. Reduced.

etatarsals. The occurrence of this species seems to point to the onclusion that Asia was the original home of the family.

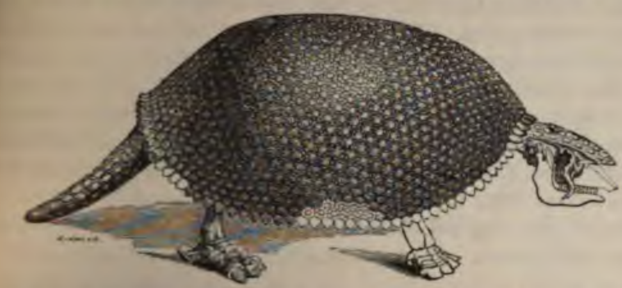
FAMILY MANIDÆ.—The Pangolins (*Manis*) of India and Africa re distinguished from all other Mammals by the body being covered uperiorly with a coat of imbricated, horny, epidermal scales. 'eeth are absent; the limbs are short and furnished with five digits, f which the terminal claws are long, curved, and bifid at the extreities. The humerus has an entepicondylar foramen, but there is o third femoral trochanter, and clavicles are wanting. The large *Manis gigantea* of Western Africa is found in a fossil state in the Pleistocene cave-deposits of Southern India; while in the Lower Pliocene of the isle of Samos we have a species three times the size of the latter, which has been made the type of the genus *Palæomanis*. A phalangeal from the Indian Siwaliks described as *Manis* appears to belong to *Chalicotherium*.

FAMILY DASYPODIDÆ.—The Armadillos (fig. 1161) of South America are characterised by the presence of a bony dorsal carapace, composed of a series of dermal scutes, of which a certain number are always arranged in movable bands, while the others may be articulated together into solid scapular and pelvic bucklers, as in fig. 1161. The frontal region of the skull also has a buckler; while the tail is defended by rings or tubercles of bone. In the existing genera the teeth are simply conical; and in *Tatusia* all except the last have milk predecessors. Many of the cervical vertebræ are anchylosed together; and the stout humerus has an entepicondylar foramen, and the femur a third trochanter. The fore-feet are provided with very strong curved claws; and, like the *Manidæ*, the existing forms are of burrowing habits. The Pleistocene cave-deposits of Brazil yield remains of some existing and some extinct species of the genera *Dasypus*, *Tatusia*, *Tolypeutes* (fig. 1161), and *Xenurus*. In the Pleistocene of Argentina we meet with a large extinct type known as *Eutatus*, which is characterised by the whole of the carapace consisting of movable bands, which are thirty-three in number. The Tertiaries of the same region have also yielded a much larger form known as *Dasypotherium*, which appears to connect the living forms with the next genus. There were eight lower teeth, of which the second appears to have been enlarged, as in some species of *Mylodon*. The most remarkable genus is, however

Fig. 1161.—The three-banded Armadillo (*Tolypeutes conurus*). South America. One-third natural size. (After Murie.)

Chlamydotherium, of the South American Pleistocene, in which t teeth approximate in structure to those of the next family. T carapace has several movable bands; and the largest species is co sidered to have equalled the bulk of a Rhinoceros. The existi Armadillos are therefore dwarfs by the side of these huge allies an earlier epoch.

FAMILY GLYPTODONTIDÆ.—In this extinct American family t body was covered by a carapace as in the Armadillos; but th carapace (fig. 1162) has no movable bands, so that the anim could not roll itself up; and since the fore-feet have short thi toes, it is evident that the habits of this group were not fossori The carapace usually has its component scutes united by sutu but in one genus they were separate; the scutes are, moreov usually ornamented with a sculpture, which varies in the differe era and species; but they may be either plain or tuberculated. ere is usually a ventral buckler (never found in the Armadillos),



ig. 1162.—*Glyptodon clavipes*; Pleistocene, South America. Reduced greatly. The tail is incorrectly restored, and it is probable that the figured portion belongs to *Hoplophorus*.

d the tail is enclosed in a complete bony sheath. The th are $\frac{8}{8}$ in number, and have two deep grooves on either side iding them into three nearly tinct lobes (fig. 1163); the neric name being derived from s grooving or fluting. The ial part of the cranium is char- erised by its extreme shortness g. 1163 *bis*); and there is a ng descending maxillary pro- ss in the zygomatic arch. Nearly the whole of the vertebral lumn is anchylosed into a long tube, but there is a complex nt at the base of the neck. This mily is mainly characteristic of uth America; but species of *lyptodon* ranged as far as Mexico d Texas into North America. reat confusion has arisen in re- ect to the classification of the lyptodonts, owing to the diffi- lty of referring isolated caudal eaths to their proper carapaces. he forms with a solid carapace ay, however, be arranged as fol- ws. In *Hoplophorus* the scutes f the carapace are sculptured, and ften comparatively thin, the peripheral series being flat; while the udal sheath has several movable rings, and terminates in a long

Fig. 1163.—Grinding surface of two teeth of *Glyptodon reticulatus*; from the Pleistocene of South America.

Fig. 1163 *bis*.—Left lateral view of the skull of *Glyptodon*; from the Pleistocene of South America. One-tenth natural size. (After Burmeister).

subcylindrical tube (fig. 1164), ornamented with a number of l
disks, surrounded by a series of much smaller ones. It is c
sidered probable that the caudal tube represented in fig. 1
belongs to this genus. The humerus has an entepicondylar fora
and there are four complete digits to each foot. An allied f
from the infra-Pampean of Patagonia, has received the name
Palæhoplophorus; while the terminal tube of a caudal sheath f
Uruguay has been made the type of the genus *Eleuthero*
The latter specimen is characterised by its loose attachment to t
enclosed vertebræ, and by the great number of perforations f
bristles, so that the tail of the living animal must have resembl
a huge bottle-brush. The genus *Panochthus* is characterised by t

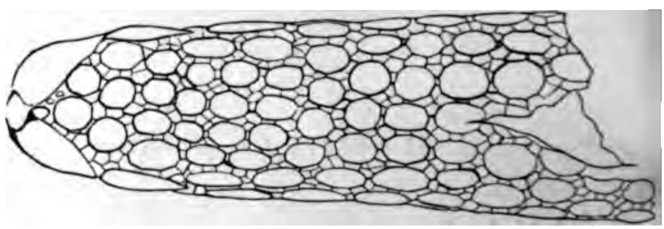


Fig. 1164.—The incomplete terminal tube of the caudal sheath of *Hoplophorus*; from the Pleistocene of South America. One-third natural size.

excessive thickness of its carapace, the scutes of which are tuberculated, and by a caudal sheath composed proximally of several movable rings, but terminating in a long compressed tube ornamented with tubercles, of which some were of very large dimensions, and marked with a radiate sculpture. In *Euryurus* the caudal sheath is of somewhat similar type, but the scutes of the carapace are simply rugose. *Dædicurus*, again, also has the scutes of the carapace rugose, but the terminal tube of the caudal sheath is enlarged into a flattened club-like expansion, covered with coarse tubercles, interspersed with a few larger rough disks having a radiate sculpture; these disks having probably been surmounted, as in *Panochthus*, with horny epidermal spines. The type species attained a length of about 12 feet. Finally, in *Glyptodon* (fig. 1162), with which *Schistopleurum* is probably identical, the scutes of the carapace had a rosette-like sculpture, the peripheral ones being raised into conical prominences, and the caudal sheath, at least in several species, was entirely composed of a series of movable rings, ornamented with large conical tubercles. The humerus was devoid of an entepicondylar foramen; and while there were five complete digits in the manus, those of the pes were reduced to four. *Thoracophorus* differs from all the foregoing in having the scutes of the carapace separated from one another, and thereby approximates ome of the *Megatheriidæ*, in which there were a number of small cles embedded in the dermis of the dorsal region. A similar con-on prevails in *Carioderma*, of the Loup-Fork beds of Texas.

AMILY MYRMECOPHAGIDÆ.—This family comprises the true -eaters of South America, represented by the genera *Myrmeco-ga*, *Tamandua*, and *Cycloturus*; but appears to be unknown in a il state. The jaws are entirely destitute of teeth; the body is hed with hair; the tail is long; there are either four or five digits he pes; and the third digit of the manus is the longest.

AMILY MEGATHERIIDÆ.—The members of this family are en-ly extinct, and are confined to the New World. They comprise umber of very large forms adapted solely for walking on the und, and showing in their skeletal organisation characters inter-liate between the preceding and the following families. Thus, le their vertebræ and limbs are constructed like those of the rmecophagidæ, their crania and dentition resemble those of the

Fig. 1165.—*Megatherium americanum*; from the Pleistocene of South America. Much reduced.

adypodidæ. One species of the genus *Scelidotherium* approxi-tes, however, in cranial characters to the former family; and it probable that the whole three families have originated from a gle stock. The number of the teeth is usually $\frac{5}{4}$; and the first l second teeth may be either in apposition or separated by an erval. The femur has no third trochanter; and the under sur-e of the odontoid process of the axis vertebra presents a peculiar tened surface for articulation with the atlas. The type genus gatherium[1] is found in the Pleistocene of both South and North

[1] This name should properly be *Megalotherium*, but its antiquity renders it ewhat sacred.

America; the typical *M. americanum* (fig. 1165) of the former region being fully equal in bulk to the largest species of Rhinoceros. The teeth (fig. 1166) consist of square prisms, wearing into transverse ridges through the presence of two vertical plates of hard dentine intercalated between softer dentine and cement; they are similar in

Fig. 1166.—*Megatherium americanum.*—Oral surface of the mandible; from the Pleistocene of Buenos Ayres. Reduced.

structure, and are all in contact. The feet are provided with powerful and huge claws, the third digit in each foot being the longest; and the humerus has no foramen.

There are indications that the snout was prolonged, and more or less flexible; and the tongue was probably prehensile. From the characters of the molar teeth it is certain that the Megathere was purely herbivorous in its habits; and from the enormous size and weight of the body it is equally certain that it could not have imitated its modern allies, the Sloths, in the feat of climbing, back downwards, amongst the trees. It is clear, therefore, that it sought its sustenance upon the ground, and it was originally supposed to have lived upon roots; but by a masterly piece of deductive reasoning, Sir R. Owen showed that this great Ground-sloth lived upon the foliage of trees, like the existing Sloths—but with this difference, that instead of climbing amongst the branches, it actually uprooted the tree bodily. In this *tour de force*, the animal sat upon its huge haunches and mighty tail, as on a tripod, and then grasping the trunk with its powerful arms, either wrenched it up by the roots or broke it short off above the ground. Marvellous as this may seem, it can be shown that every detail in the skeleton of the Megathere accords with the supposition that it obtained its food in this way.

A smaller but allied form from the Pleistocene of South America has been named *Oracanthus*, but since this term is preoccupied by a genus of Palæozoic Fishes, it should be changed. The genus *Scelidotherium* (fig. 1167), which may be taken to include *Platyonyx*, and likewise occurs in the South American Pleistocene, comprises a number of species, and has characters in some respects intermediate between the preceding and the following genera. The teeth in the upper jaw have an irregularly oval section, while those of the mandible are usually subtriangular; the whole of the series are in contact, and their crowns do not wear into ridges. The

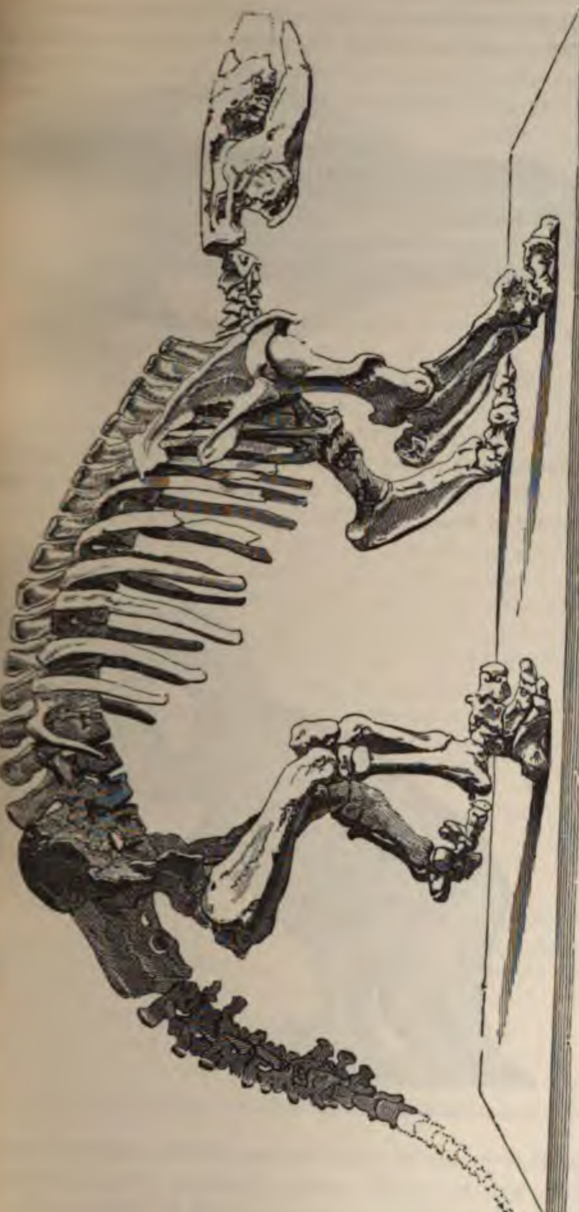


Fig. 1167.—The imperfect skeleton of *Scelidotherium*; from the Pleistocene of South America. One-sixteenth natural size. (After Capellini.)

cranium is low and elongated; and, especially in the type spe[...] (fig. 1168), approximates to that of the *Myrmecophagidæ*. Th[...] length of the nasals is subject to great variation in the differ[...]

Fig. 1168.—Frontal aspect of the cranium of *Scelidotherium leptocephalum*; from the Pleistocene of South America. One-sixth natural size.

species. The structure of the feet shows a marked deviation fro[m] that of *Megatherium*; and the humerus was usually provided w[ith] a foramen. The figure of the skeleton is taken from a specim[en] in the museum at Bologna. The genus *Mylodon* (fig. 1169) co[m-]

Fig. 1169.—*Mylodon robustus*; from the Pleistocene of South America. Much reduced.

prises another group of large Ground-Sloths, which has been [s]plit up by some writers into the genera *Lestodon*, *Pseudolestodon*, *Gr[ypo]therium*, &c., according to certain not very important difference[s] structure and mode of arrangement of the teeth. In the upper the teeth are usually subtriangular or oval in transverse section, in typical species there is only a short interval between the first second tooth in each jaw, and the former is worn horizontally; in other species there is a considerable interval between the and the first is worn obliquely, as in certain Sloths. The erus has no entepicondylar foramen; and in the shortness of skull and the characters of the teeth this genus approaches er to the modern Sloths than any other member of the family. best known species is the South American *Mylodon robustus* 1169), which was smaller than *Megatherium americanum*, its th being about 11 feet; but *M. armatus* (the type of the so-d *Lestodon*), from the same country, is considerably larger. The species is *M. Harlani*, from the Pleistocene of "Big-bone ," in Kentucky, North America; while the Patagonian *M. rwini* is a very aberrant form, regarded by some writers as erically distinct, and named *Grypotherium*. There are numer- small dermal scutes, which do not articulate with one another. *alonyx*, from the Pleistocene of North America, is an allied us, characterised by the long interval between the large first and smaller second tooth, and also by the presence of an entepi- dylar foramen to the humerus. The type species is *M. Jeffer-* , from Kentucky and Tennessee; while *M. cubensis*, from the stocene of Cuba, has been separated by some writers under name of *Megalochnus* (*Myomorphus*). Another form hitherto wn as *Cœlodon*, but which may be named *Nothrotherium*, on ount of the preoccupation of the former term, occurs in the Pleis- ene cave-deposits of Brazil, and agrees with *Megalonyx* in the icture of its limbs, but has teeth of the type of those of *Mega-rium*, although their number is reduced to $\frac{4}{3}$; the type species siderably exceeded in size the largest Ant-eater of the present .

The Mammals from the Lower Pliocene and Miocene of North ierica which have received the names *Moropus* and *Morotherium*, l are regarded by Professor Marsh as forming the type of a tinct family of Edentates—the *Moropodidæ*—probably belong to Ungulate family *Chalicotheriidæ*.

FAMILY BRADYPODIDÆ.—This family is entirely confined to South erica, and now comprises two genera of comparatively small nals which are of exclusively arboreal habits. The body is hed with coarse hair; the teeth are $\frac{5}{4}$ in number in each jaw, are of subcylindrical form, with a central axis of soft dentine, surrounded by a coat of a harder kind of the same substance. fore-limbs are enormously elongated; and both the manus ar are furnished with long, curved claws; the number of digits exceeding three in each foot. The skull (fig. 1170) is short, descending maxillary process to the zygoma; and the tail is mentary. In *Bradypus* (fig. 1170) the first tooth is equal in the second, and is worn horizontally; while the digits are r to two. In *Cholœpus*, however, the first tooth is considerably than the second, from which it is separated by a much interval than in *Bradypus*, and wears obliquely; while the three digits to each foot. The only known fossil form is fr

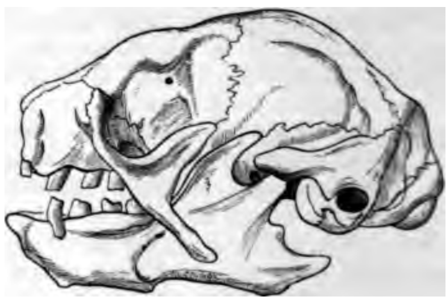


Fig. 1170.—Skull of *Bradypus gularis*. Recent. South America. Reduced

Pleistocene of Argentina, and has been named *Nothropus p* it appears to have been about twice the bulk of *Bradypus did* and has the first lower tooth separated by a very long interva the second, although it is of smaller size; the cranium, dentition, and feet are unknown.

ORDER IV. CETACEA.—The Cetacea form, perhaps, the readily defined and sharply differentiated order in the whole Their contour is fish-like, the body being fusiform, and passi perceptibly into the head without any distinct external nec posteriorly gradually tapering to the extremity of the tail, wl furnished with a pair of horizontally-expanded "flukes," for dense fibrous tissue covered with skin (fig. 1178). The h frequently very large, and may be as much as one-third th length of the animal. The pectoral limbs are reduced to paddle-like, organs; and there are no external traces of pelvic The skin is smooth and without hair; although bristles n present in the neighbourhood of the mouth, more especi young individuals. Frequently there is a median dorsal f 1178), which however has no bony supports. Both the eye a external auditory aperture are small; the former having no nic membrane, and the latter no pinna. The nostrils open by a louble aperture usually near the vertex of the skull. The bones usually of a spongy nature, and contain a large amount of oil. e cervical region of the vertebral column is always very short; the seven component elements may be partially or completely ed together, while the odontoid process of the axis when present hort and blunt, and may be entirely want- None of the vertebræ unite to form a um. The lumbar and caudal vertebræ large and numerous, and from the ab- e of zygapophysial articulations allow of rge amount of motion in the hinder part he body; the presence of chevron-bones nguishes the caudals from the lumbars. terminal epiphyses of the vertebræ do unite with the centra till the animal is adult. The cranium presents peculiar ures which it will not be necessary to ribe here; although it may be mentioned the usually small nasals are generally ight up near to the vertex, and that there more or less elongated rostrum in ad- ce of the external nares, formed by the naxilla, maxilla, mesethmoid, and vomer. vicles are absent; the scapula and hu- us are well developed and freely mov- upon one another, but the anterior es of the limb admit of only a very ht amount of movement. There are ally five digits in the manus (fig. 1171), these may be reduced to four; the langeals are unique among Mammals in eeding the number of three to a single it, and also in being furnished with epi- yses. The pelvis is represented by a pair styliform bones, which are regarded as ischia; and there are occasionally small ifications or cartilages representing the orted bones of the proximal part of the nd limb. Teeth are usually present, but t very variable in number and size. The dentition in existing rms is homœodont and monophyodont, but it was heterodont the extinct *Zeuglodontidæ* of the Eocene.

Fig. 1171.—Dorsal aspect of the left pectoral limb of the Black-fish (*Globicephalus melas*). Reduced. *r*, Radius; *u*, Ulna; *c*, Carpus (the letter placed on the scaphoid or radiale); *m*1-*m*5, Metacarpus; I.-V., Phalangeals. (After Flower.)

The Cetacea are not known with certainty before the Eocene, nd are most abundant in the later Tertiary periods. The denti- on of the Eocene *Zeuglodontidæ* indicates that the order has been probably derived from Mammals with a heterodont dentiti Professor Flower comes to the conclusion that it is most that their ancestors were allied to the Ungulata; while absence of Cetacean remains in the Cretaceous the same thinks that the earlier members of the order were ir of freshwater. With the exception of the *Platanistidæ* ; *Delphinidæ*, all existing Cetaceans are of marine or habits.

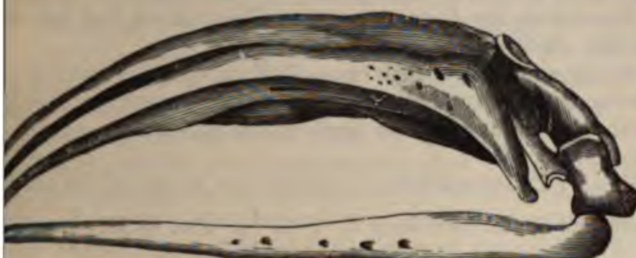
In their increased number of phalangeals (hyperphalar Cetacea resemble the Reptilian *Ichthyosauridæ* and *Plesiosa* from this circumstance, coupled with their simple type of te been argued that they represent the most archaic type of Mar even that they are directly descended from the Ichthyosaurs. mentioned there are, however, many practically decisive ob these views.

For the determination of fossil Cetaceans the solid tym petrosal bones of the internal ear, and less frequently t rostrum, are of especial importance, since these parts are well preserved.

SUBORDER I. MYSTACOCETI.—In this suborder, commo as the Whalebone Whales, functional teeth are never p though germs may be in the gums; "baleen' bone is always attach palate; the tympanic 1172) is anchylosed t otic and involuted u the nasal passages ar by the nasals, the la small and distinct jugal; and the rami o dible are laterally c do not meet in a sym

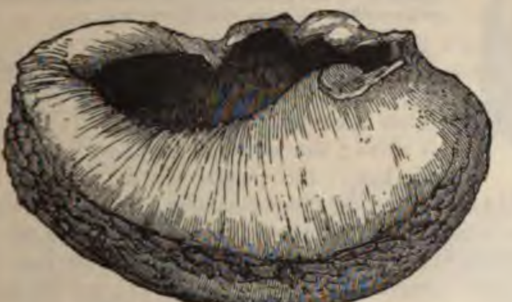
Fig. 1172.—Inner view of the right tympanic of the Greenland Whale (*Balæna mystacetus*). One-third natural size. (After Gray.)

FAMILY BALÆNII only family of this may be divided into *nine* and *Balænopt* tions. In the first of is often no dorsal fin, the tympanic (fig. 1172) has a ch flattened and angulated shape, and some or all of the c tebræ are at least usually fused together. Remains of *Balæna* (including *Balænotus* and *Balænula*) occur abu the Pliocene, and especially in the English and Belgian C of these fossil species (*B. affinis*) is closely allied to the Whale (fig. 1173); while *B. primigenia* is more nearly ght Whales of the Southern Seas. *Palæocetus*, which has been ed by its describer as of Mesozoic age, may be provisionally l to this section; the type was probably obtained from the rag. In the *Balænopterine* section a dorsal fin is very gene-esent (whence the name "Finners" applied to many of these



173.—Left lateral view of the skull of the Greenland Whale (*Balæna mystacetus*). Greatly reduced. (After Owen.)

); the cervical vertebræ are free, and thicker than in the *ne* section; and the tympanic (fig. 1174) is longer, more in-nd more rounded than in the latter. The existing genus *ra* (in which may be included the fossil *Burtinopsis*) is ntly represented in the Pliocene Crags of both England and n. *Balænoptera* also occurs commonly in the same deposits; *ita* being apparently nearly allied to the existing *B. sibbaldi*,



1174.—Inner view of the right tympanic of a Rorqual (*Balænoptera musculus*). Recent. One-half natural size. (After Gray.)

ttains a length of 80 feet; while *B. emarginata* comes nearer iving *B. rostrata*, which is seldom more than 30 feet in length, *rium* (including *Cetotheriophanes*, *Plesiocetus*, and *Plesiocet-* s characterised by the narrowing of the anterior extremity of npanic, and is likewise found in the Crags and other Pliocene

beds; while *Herpetocetus* from the same deposits is an allied g
with an egg-shaped tympanic, and a talon to the mandibular co
which recalls that of *Physeter*. The names *Amphicetus*, *Idi*
Isocetus, *Heterocetus*, and *Mesocetus*, have been applied to Ceta
from the Belgian Crag, most or all which may apparently l
cluded in *Cetotherium*. Lastly, a vertebra from the Upper E
of Hampshire has been referred to *Balænoptera*, but this refe
requires confirmation.

SUBORDER 2. ARCHÆOCETI.—This suborder is confined
Eocene and Lower Miocene, and may be characterised by th
nasals, and the presence of teeth differentiated into groups i
jaws.

FAMILY ZEUGLODONTIDÆ.—In the one genus of the only
family the dental formula is $I.\ \frac{3}{3},\ C.\ \frac{1}{1},\ Pm. + M.\ \frac{5}{5}$. Th
ting-teeth are simple and pointed; but the cheek-teeth (fig.

Fig. 1175.—*Zeuglodon cetoides*; from the Middle Eocene America. A, Left lateral aspect of cranium, much reduced; B, molar tooth less reduced. (After Gaudry.)

have two distinct roots, and compressed, p
crowns with denticulated cutting-edges. T
nium is elongated and depressed; the brai
is small; the temporal fossæ and the sagitt
are large; the cranial rostrum is long, and
sides largely composed of the premaxillæ; the nasals are lo
and narrow; and the external nares are placed more anterior
in living Cetaceans. All the cervical vertebræ are free, whil
of the lumbar region are unusually elongated; but the nature
limbs is not known. In their dentition, as well as in the cha
of the skull—especially the long nasals and the forward posi
the nares—the Zeuglodonts depart less markedly from the g
plan of Mammalian structure than any existing members
order; and it is remarkable that the Mystacoceti show a nea
semblance in cranial structure to these fossils than is made
Odontoceti. The one genus *Zeuglodon* is known from the
Tertiaries of Egypt, England, and North America; the rem

ical *Z. cetoides* being extraordinarily abundant in parts of the ›untry, where they have been weathered out of a deposit of Eocene age.

RDER 3. ODONTOCETI.—All living Cetaceans not included in tacoceti belong to this suborder, which is characterised by ence of calcified teeth after birth; the functional ones being numerous, but sometimes reduced to a single pair (occa- wanting). Baleen, or whalebone, is invariably absent; the is more or less unsymmetrical; the nasals are reduced to ny nodules which do not roof over the narial passages; the l is either united to the jugal, or of very large size; and dibular rami are nearly straight, and meet in a median sym- The tympanic is not anchylosed to the periotic, and has ompletely involuted structure found in the Mystacoceti.

.Y PHYSETERIDÆ.—In this family there are no functional the upper jaw; and the anterior facet of the periotic for on with the tympanic is smooth (fig. 1176), while the pos- npanic surface of the former bone is broad, with a distinct idge. In recent genera some or all of the cervical vertebræ l together. This family is divided into the two subfamilies *næ* and *Ziphiinæ*. In the former, which comprises the Cachalot, or Sperm Whale (*Physeter*), and the Short-nosed (*Cogia*), the mandibular teeth are numerous and implanted groove partly divided by imperfect septa. Remains of the Sperm Whale (*P. macrocephalus*) are found in the English ed, and also in the Pleistocene of South America; the large ve no enamel at their summit. Allied to this genus are from the English and Belgian Crags, and *Physetodon* from ene of Australia; while *Physeterula* is a genus founded on from the former deposits, which does not exceed some 20 ength. A number of Pliocene and Miocene forms appa- llied to the Cachalot, h the crowns of the ped with enamel, have scribed as *Balænodon*, *s*, *Hoplocetus*, *Physodon*, *hioides*; *Hoplocetus* and comprise comparatively ecies from the English ian Crags and the French ; while *Ziphioides* is from le Miocene of Baltringen mberg. In the Ziphiine subfamily, comprising the existing sed (*Hyperöodon*) and Beaked-Whales (*Ziphius* and *Meso-* all the mandibular teeth, with the exception of one or

Fig. 1176.—The left periotic of *Mesoplodon longirostris*; from the Suffolk Crag.

occasionally two pairs, are rudimentary. *Hyperöodon* is represe
in the Crags of England and Belgium. These beds also yield
extinct genus *Choneziphius*, as well as several species belongin
the living genus *Mesoplodon*, which is distinguished from C
ziphius by the complete ossification in the adult of all the ele
comprising the cranial rostrum. The Crag species of *Mesop*
are mainly known by these solid rostra, which in the living s
are composed of dense ivory-like bone, and are the most solid
found in the whole of the Vertebrata. The periotics (fig. 117
more rarely found, but are equally characteristic.

FAMILY PLATANISTIDÆ.—This family, which is now repre
by *Platanista* of the Ganges, and *Inia* and *Pontoporia* of th
rivers of South America, is characterised by the large num
simple teeth in the elongated jaws, and by the length of th
dibular symphysis exceeding half that of the entire mandible.
of the cervical vertebræ are anchylosed together. Remain
to *Pontoporia* were found by Bravard in the Pleistocene of
America, but these are referred by some authorities to a
genus under the name of *Pontistes* or *Palæopontoporia*. The
genera *Champsodelphis* and *Schizodelphis*, of the European Pl
are usually referred to this family, but the latter approximates
Delphinidæ.

FAMILY SQUALODONTIDÆ.—The extinct Squalodonts we
merly classed with the *Zeuglodontidæ*, but the characters
cranium are essentially Delphinoid, although the teeth are dif

Fig. 1177.—Three lower molars of *Squalodon*; from the Miocene of Europe.

ated into groups as in the former. The type genus *Squalodon*
from the Middle Miocene to the Pleistocene of Europe, and
found in the Tertiaries of North America, New Zealand, an
tralia. The teeth may be arranged as $I. \frac{3}{3}$, $C. \frac{1}{1}$, $Pm. \frac{4}{4}$,
the premolars are simple, but the true molars (fig. 1177
double roots, and crowns very like those of *Zeuglodon*, al

tinguished by the denticulations being more developed on the sterior than on the anterior border. The so-called *Rhizoprion* is rely a species of this genus.

FAMILY DELPHINIDÆ.—In this, the last family of the Cetacea, teeth are simple, and usually numerous in both jaws; and the gth of the mandibular symphysis may be very small, and never ceeds one-third of that of the entire ramus. The periotics (fig. 79), which are frequently found in a fossil condition, are dily distinguished from those of the *Physeteridæ*, by having the erior facet which articulates with the tympanic marked by a

Fig. 1178.—The common Dolphin (*Delphinus delphis*). Reduced.

ber of grooves, as well as by the narrowness of the posterior of their tympanic aspect. This family comprises all the Ceta-s commonly known as Porpoises, Grampuses, Killers, and Dol-s. Remains of the Narwhal (*Monodon monoceros*) are found he Norfolk Forest-bed and the Pleistocene of Alaska. The s *Delphinapterus*, now represented by the "White Whale," rs in the Lower Pliocene of Tuscany, as well as in the Pliocene Miocene of other parts of Europe. An extinct species of ller-Whale" (*Orca*) is found in both the Italian and English cene. The existing *Globicephalus s*, or "Black-fish," has left its re-s in the superficial deposits of x; while the extinct *G. uncidens* rs in the Suffolk Crags. A left otic of the latter species is repre-ed in fig. 1179, in order to show features characteristic of this family. existing *Pseudorca crassidens* was nally described from a subfossil ium found in the fens of Lincoln-. Of the smaller Dolphins it is probable that the genera *siops*, *Lagenorhynchus*, and *Delphinus* (as now restricted) are all esented in the Pliocene of Europe. *Eurhinodelphis* is a long-ited genus from the Pliocene of Belgium and Italy, which is

Fig. 1179.—The left periotic of *Globicephalus uncidens*; from the Coralline Crag of Suffolk.

probably nearly related to the existing *Steno*. Delphinoid remai
from the Miocene of North America have been described by Pro
fessors Leidy and Cope under the names of *Priscodelphinus*, *Tetr*
sphys, *Zarhachis*, *Lophocetus*, *Rhabdosteus*, *Ixacanthus*, *Anoplonass*

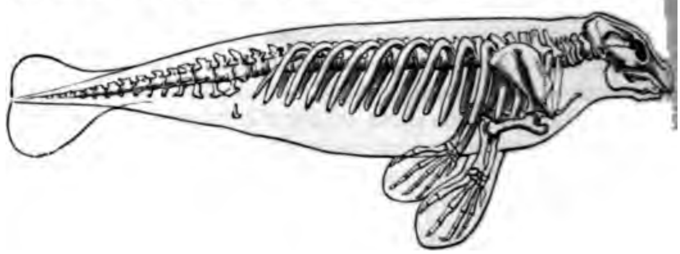


Fig. 1180.—Skeleton of the Manatee (*Manatus australis*). Greatly reduced.

and *Orycterocetus;* but further information is required as to t
affinity of these forms and their right to generic distinction.

ORDER V. SIRENIA.—The Sirenia, now represented only by t
Manatees and Dugongs, agree with the Cetacea in their adaptati
for a purely aquatic life, and accordingly present a strong gene
resemblance in their external contour to the members of that ord
The head is, however, of normal relative size; the tail has a h

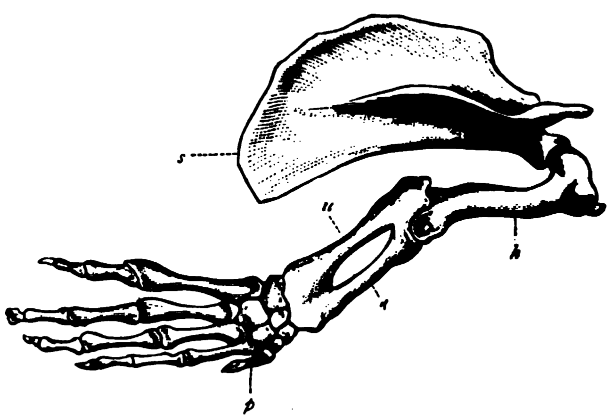


Fig. 1181.—Dorsal view of the right pectoral limb of *Manatus australis*. Much reduced
s, Scapula; *h*, Humerus; *r*, Radius; *u*, Ulna; *p*, Pollex.

zontal membranous expansion; the pectoral limbs, although modifi
into paddles (fig. 1181), retain the normal number of phalangea
all external traces of the pelvic limbs are wanting; and the surfa
of the body is either naked or covered with sparse bristles. T
lips are fleshy; the nostrils placed near the extremity of the muz

1180); the eyes minute; and the small ear has no external
. The bones of the skeleton are extremely dense and solid;
ervical vertebræ may be reduced to six, but are never anchy-
together; and the axis has a well-developed odontoid process.
ertebræ have no epiphyses; and none of them unite to form
um. Large chevron-bones are present. Clavicles are want-
nd no recent forms show any trace of the femur, although a
rm rudiment of this bone is found in the extinct *Halitherium*.
wo bones of the forearm in the existing genera (fig. 1181) are
ual in size, and frequently anchylosed together. In recent
the skull (fig. 1182) is remarkable for the upward direction

2.—Right lateral view of the skulls of *Halicore* (A) and *Manatus* (B). Much reduced.

narial aperture, and for the absence or rudimental condition
nasals. The teeth can only be differentiated in the living
into incisors and cheek-teeth, which are separated from one
r by a long interval; but in one fossil genus there is a more
ete dental series; while in *Rhytina* these organs were totally
g. In the existing genera the dentition is monophyodont,
ilk-molars occur in *Halitherium*. This order is known from
ocene upwards, but appears to have been steadily dying out
present period. The fossil forms, although decidedly more
lised than their living representatives, do not at present afford
ear indication as to the origin of the order.

MILY HALICORIDÆ.—In this family the one existing genus
re (Dugongs) has the deflected premaxillæ (fig. 1182, A) fur-
l with a pair of large tusk-like incisors; and there are also
airs of functionless germs of cutting-teeth in the similarly de-
l mandibular symphysis. Five or six cheek-teeth are devel-
in each jaw, which are usually cylindrical, and all grow from
tent pulps, and are not coated with enamel. The Dugongs
it the coasts of the Red Sea and the Indian Ocean. *Prohali-*
rom the Pliocene of France, is regarded as nearly allied to the
g genus. The only other form which has been referred to
amily is known by a molar from the Tertiary of California,
has been described by Professor Marsh under the name of

Desmotylus. Further information is, however, required before thi reference can be definitely accepted.

FAMILY HALITHERIIDÆ.—The fossil forms constituting the *Hali-theriidæ* are characterised by the presence of upper incisors; by the cheek-teeth being coated with enamel, like those of the *Manatidæ*; and by the retention, in at least some cases, of a milk dentition.

Fig. 1183.—Grinding surface of the penultimate and last right lower molars of *Halitherium fossile*; from the European Miocene.

In the type genus *Halitherium* (which may be taken to inclu *Halianassa*, *Pugmeodon*, and *Felsinotherium*) there is a pair of tu like upper incisors, and either five or six cheek-teeth in each ja small nasals are present in at least some of the species; the p maxillæ and mandibular symphysis are bent downwards; there i descending plate at the angle of the mandible; and a small rod-l ossification represents the femur. The molars (fig. 1183) hav pattern on their grinding surface resembling that of *Hippopotan*

Fig. 1184.—Skeleton of *Halitherium Schinzi*; from the Lower Miocene of Hessen-Darms Much reduced.[1]

This genus ranges from the Lower Miocene (Middle Oligoc to the Lower Pliocene of Europe; and remains of *H. Sch* (fig. 1184) are especially abundant in the Lower Miocene sa of certain districts of Hessen - Darmstadt. *Prorastomus*, fr Tertiary strata in the West Indies, is a generalised form appare

[1] In this figure the deflection of the premaxillæ is omitted.

Halitherium, but with a fuller dentition, and without the deflection of the extremities of the jaws. The dentition . $\frac{1}{1}$, *Pm.*+*M.* $\frac{7 \text{ or } 8}{7 \text{ or } 8}$; the upper incisors are not tusk-like; cheek-teeth have simple transverse ridges somewhat like the Ungulate genera *Dinotherium* and *Listriodon*. *Eo-* is definitely known by a cast of the brain-cavity from the f Egypt, but teeth from the same deposits described under of *Manatus* may perhaps belong to it; its affinities cannot roperly determined. Probably allied to *Halitherium* is *rium* from the Pliocene of Belgium; while *Dioplotherium* Miocene of South Carolina is regarded as intermediate *Halicore* and *Halitherium*.

y Rhytinidæ.—The *Rhytinidæ* are known only by the *ytina gigas*, or Steller's Sea-Cow, which was formerly very on Behring and Copper Islands in the North Pacific, nmonly supposed to have been exterminated about 1768, a few individuals may have lingered on to a considerably . The Rhytina attained a length of from 20 to 25 feet, haracterised by the entire absence of teeth, their function pplied by horny plates (cornules) on the palate. The head nall in proportion to the length of the body; and has the æ and mandibular symphysis moderately deflected. The naked, and covered with a rugged epidermis resembling of a tree. Nearly entire skeletons have been obtained peat of Behring Island.

y Manatidæ.—In *Manatus*, the only known representative nily, the premaxillæ and mandibular symphysis (fig. 1182, B) eflected, and there are no functional incisors. The cervical are reduced to six; the cheek-teeth, which are coated with nd carry two transverse ridges, may be as many as eleven aw, although it is seldom that more than six are present ne time. The Manatees are inhabitants of the mouths ries of the great rivers discharging into the two sides of tic. No fossil forms are known which can be referred ainty to this family, although the type generic name has lied to certain teeth from the Eocene of Egypt already d.

nians of uncertain affinity may be mentioned *Chronozoum* later Tertiary of New South Wales; *Hemicaulodon* from ne of Shark River; *Pachyacanthus* from the Miocene of and *Trachytherium* (with which *Rhytiodus* may perhaps be from that of France.

CHAPTER LXI.

CLASS MAMMALIA—continued.

ORDER UNGULATA.

ORDER VI. UNGULATA.—The Ungulata, or Hoofed Mammals, c stitute the largest and one of the most important orders into wh the class is divided; all the included groups being so connec together as to preclude their division into well-defined sepa orders. This order comprises at least seven suborders, of whi three are totally extinct, while all the others, with the exception the Hyracoidea, have lost a large number of family types at t present day. The two first suborders—Artiodactyla and Peris dactyla—present several features in common, and are according brigaded together by some authorities under the names of Ungul Vera, Clinodactyla, or Diplarthra; while all the others are inclu in a second division under the name of Subungulata.

All the members of this order are adapted for a terrestrial and in the main for a vegetable diet, although a few are mo less omnivorous. Their dentition is heterodont and diphyo and the milk-set is well developed, and not changed till la life; and in the Perissodactyla alone among Mammals do we certain instances where the whole four premolars are precede milk-teeth. The cheek-teeth of the more typical forms have b crowns, with either tuberculated or ridged surfaces; and their cr are very frequently interpenetrated by deep folds of enamel, w produce a complicated pattern on their worn surfaces. Exce *Typotherium*, clavicles are always wanting. The toes, with th ception of *Chalicotherium*, are provided either with blunt, b nails, or with hoofs more or less completely encasing the ter phalangeals. The feet of existing types are digitigrade, and number of the toes varies from five to one. In all existing f the humerus has no entepicondylar foramen. The scaphoid bones of the carpus are always distinct; but the radius and nay unite.

he great majority of instances the cheek-teeth are rooted, and suborders Artiodactyla, Perissodactyla, and Proboscidea, which ise the most specialised members of the order, a gradual in- in the height of the crowns of these teeth may be traced the generalised to the specialised genera. Those teeth in the crowns are low, and their whole structure is visible from inding surface, being known as *brachydont* (compare fig. 1195); those with high crowns, in which the bases of the enamel-folds visible from the grinding surface, are termed *hypsodont* (fig. . The change from a brachydont to a hypsodont dentition ompanied by the production of a nearly flat and horizontal ng surface in the cheek-teeth, in place of a more or less ly ridged one; the more specialised type being adapted for a t grinding action of the upper against the lower teeth, while more generalised type the action is to a great extent a snap- one. Examples of the former type are shown by the Horse Ox, and of the latter by the Pig and Hyrax. Hypsodontism t confined to this order, as will be noticed in the sequel.

me remarks on the probable origin of the order are made w under the head of the Condylarthra. In the specialised s there is very often a tendency to a suppression of the anterior h, more especially in the lower jaw.

SUBORDER I. ARTIODACTYLA. — This and the next suborder sent certain structural modifications of the extremities, by which y are distinguished from the remaining five suborders, and on ch account, as already mentioned, they are grouped together by e writers under the name of Ungulata Vera, or Diplarthra. s the feet are never plantigrade, and the number of functional s does not exceed four. In the carpus (fig. 1185) the scaphoid pported by and largely articulates with the magnum; while the (together with the unciform) supports the lunar, and has no ction with the cuneiform. In the tarsus the cuboid extends ly to articulate with the astragalus, which is deeply grooved 186). All the component bones of both the carpus and strongly interlock, which makes the structure of these joints omplex than in the other suborders. Finally, the jugal forms erior part of the zygomatic arch (fig. 1187), and the brain is ively large size and complex structure.

suborder, so far as at present known, is distinguished e Perissodactyla by the distal surface of the astragalus (fig. being ginglymoid, by the third and fourth digits (fig. 1185) equal in size, and arranged symmetrically on either side of drawn between them; by the absence of a third trochanter to the femur; and by the articulation of the fibula with the caneum. In all existing forms the number of the dorso-lu

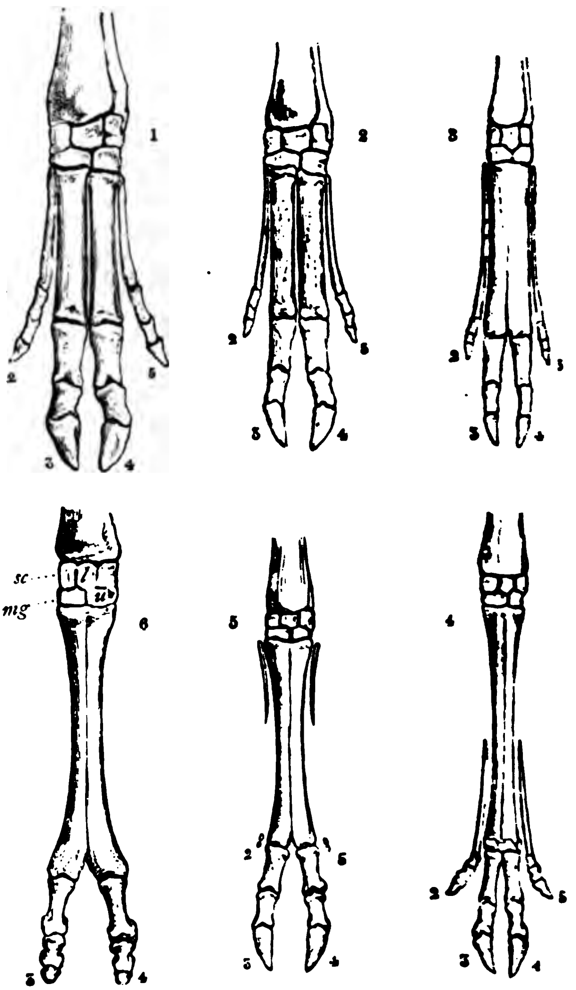


Fig. 1185.—Left manus of (1) Pig (*Sus*), (2) *Hyomoschus*, (3) Chevrotain (*Tragulus*) buck (*Capreolus*), (5) Sheep (*Ovis*), and (6) Camel (*Camelus*). In the carpus the middl the upper row is the lunar, the left the scaphoid, and the right the cuneiform; in the se the left bone is the magnum, and the right the unciform. Reduced. (After Daw Oakley.)

vertebræ is nineteen; and the nasals are not expanded poste In the dentition the first tooth of the cheek series never deciduous predecessor. The upper premolars are very ge nple in structure than the true molars; while the last lower lar nearly always has a third lobe, the same feature being l in the last lower tooth of the milk series.

e Pecora the pelvis (fig. 1128 *bis*) is characterised by the igth of the ilia, which are not much expanded; but in the otamus these bones are shorter and more expanded, and thus nate to those of the Perissodactyla. The symphysis of the nd pubes is much elongated.

e molars in the upper jaw ner four or five main columns; ess specialised forms such as s (figs. 1194, 1195), such in both upper and lower orm low subconical tubercles, ie dentition is termed *buno-* ut in others, such as *Eporeo-* . 1201) and the Ruminants o), the outer pair of columns transversely flattened, and er pair crescent-shaped, and tition is then termed *seleno-* n the lower molars of the oe of dentition it is the inner that become flattened, while er ones assume a crescent There is, however, a complete passage from the one type ther; the most specialised forms with a hypso-selenodont n being of comparatively recent origin. The existing mem- this suborder are divided into the sections Suina (Pigs ppopotamus), Tylopoda (Camels), Tragulina (Chevrotains), ora (typical Ruminants); but since such divisions will not od for the fossil forms, it will be convenient merely to he suborder into families.

Fig. 1186.—Left astragalus of a Ruminant Artiodactyle (*Bos*). Reduced.

uld, moreover, be observed that it is by no means certain the above-mentioned characters will apply to some of the wn earlier members of the suborder, since some of these l in the *Anoplotheriidæ* present certain remote indications of with the Perissodactyla.

dvance from a bunodont to a hypso-selenodont dentition is nied in this suborder by a tendency in the second and third lials to coalesce into a *cannon-bone*, and also by a change in of the odontoid process of the axis vertebra from a peg-like on to a spout-like demicylinder. The earliest form which n referred to this suborder is the small *Pantolestes*, from the Eocene of the United States. This genus is still very imperfectly known; but Professor Cope, who makes it the type of a distinct family, states that it has tritubercular upper molars, and four digits in the pes, and looks upon it as the ancestral type of the Camels. Dr Schlosser is, however, not satisfied that the teeth are

Fig. 1187.—Left aspect of the Hippopotamus (*H. amphibius*). Much reduced. (After Giebel.)

really tritubercular, and suggests that it may indicate a transitional type between the Artiodactyla and the Condylarthra.

FAMILY HIPPOPOTAMIDÆ.—This family contains the single Old World genus *Hippopotamus*, now represented by two species of

Fig. 1188.—Left manus of *Hippopotamus amphibius*. Reduced. (After Cuvier.)

Fig. 1189.—Left upper true molar of *Hippopotamus amphibius*. Two-thirds natural size.

bulky animals, which spend a large proportion of their time in the waters of lakes and rivers. In the skull (fig. 1187) the angle of the mandible has a descending flange; the facial portion is much elo nd the orbits are tubular and very prominent. The dental is $I. \frac{(2-3)}{(1-3)}, C. \frac{1}{1}, Pm. \frac{4}{4}, M. \frac{3}{3}$. The cheek-teeth are in structure; the true molars (fig. 1189) having four which present trefoil-shaped dentine surfaces when worn; olars are simpler. The upper incisors are short and ver- 1187), but those of the lower jaw are procumbent, and ery large (fig. 1191). The canines of the upper jaw are pwards like those of pigs, while the lower ones are of s size, and have their extremities obliquely worn to a cutting-

—*Hippopotamus sivalensis*; from the Pliocene of the Siwalik hills. *a*, Palatal cranium; *b*, Third right upper true molar; *c*, Symphysis of mandible. Reduced.

biting against the outer surfaces of those of the upper jaw. (fig. 1188) are short and massive, and furnished with four which the terminal phalangeals bear nail-like hoofs. The nearly naked and of great thickness; while the ears and very small, and the tail is short.

more generalised forms like *H. sivalensis* (fig. 1190), of the of the Siwalik Hills of India, there are three pairs of incisors in , all of which are of subequal size. This hexaprotodont group nted in the Pliocene of Burma by *H. iravaticus*, and in that of y *H. bonariensis*; while its latest member is *H. namadicus*, of ocene of the Narbada Valley, in India. In the latter deposits also occurs *H. palæindicus*, in which the second lower incisor is minute, and perhaps disappears in the adult; while in the existi *amphibius* of Africa, which is found fossil in Europe from the Pliocene of the Val d'Arno to the late Pleistocene, there are o pairs of incisors in each jaw, the innermost pair in the mandibl of enormous dimensions (fig. 1191). It is evident from the c prevailing in *H. palæindicus* that it is the second pair of inciso is missing in the existing species. Allied to, but smaller than th are *H. Pentlandi* and *H. minutus*, whose remains are found in e quantities in the caves of Italy and the Mediterranean islands.

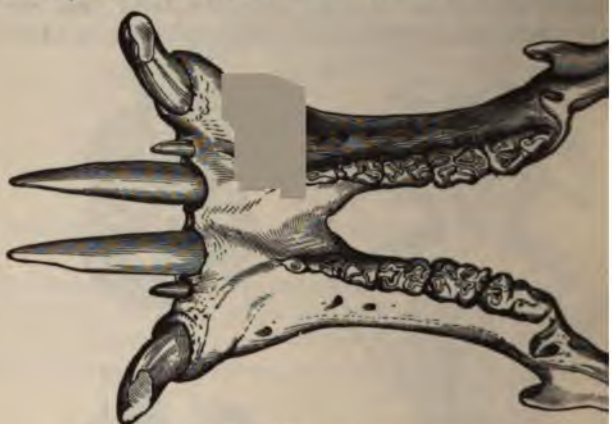


Fig. 1191.—Mandible of *Hippopotamus amphibius*. Reduced.

in the small *H. liberiensis*, now living in West Africa, the n lower incisors is reduced to a single pair. The resemblance of dible of *Hippopotamus* to that of the *Anthracotheriidæ* sugg both are derived from a common ancestor.

FAMILY SUIDÆ.—This family may be taken to include existing *Dicotylidæ* and *Phacochæridæ* and the extinct *Listri* since fossil forms indicate a close connection between all the The cheek-teeth are typically bunodont and brachydont, t true molars carrying four main columns, which may be eithe (fig. 1195) or of extreme complexity (*Hippohyus*), but whic wear into distinct trefoils. Their outer and inner colum however, coalesce into transverse ridges (fig. 1193). T (fig. 1192) has a more or less elevated supraoccipital regi which the profile slopes away to the muzzle, the nasals b quently much elongated; while the mandible has no de flange at the angle. The canines are frequently large and (fig. 1192), the superior ones being curved upwards, and t ones biting against a facet on the outer surface of the upp but in many of the earlier forms, and in the recent Pecca

ent of these teeth is much less marked. The digits are
ır in number, but in the existing forms (fig. 1185) only

—Right lateral aspect of the skull of the Wild-boar (*Sus scrofa*). Reduced. (After Gray.)

ddle ones touch the ground. The dental formula is very
ne typical one.

nct genus *Listriodon* differs from all the other members
ily in that the true molars (fig. 1193) carry a pair of
sverse ridges. The dental formula is

Pm. $\frac{3}{3}$, *M.* $\frac{3}{3}$; the canines form large
last upper premolar is simpler than
olars; and the anterior premolars are
ide. The skull is essentially that of
Remains of *Listriodon* occur in the
iocene of the Continent (where they
described under the names of *Lophio-*
Tapirotherium), and also in the Plio-
iks of the Punjab and Sind. The
ent the same relation to those of *Sus*
by the molars of *Dinotherium* to those of many species
n.

Fig. 1193.—The second left upper true molar of *Listriodon splendens*; from the Middle Miocene of France.

this aberrant type, we may turn to the typical genus *Sus*,
he normal dental formula is *I.* $\frac{3}{3}$, *C.* $\frac{1}{1}$, *Pm.* $\frac{4}{4}$, *M.* $\frac{3}{3}$,
ie first premolar is absent in some fossil species, and also
ican *Potamochœrus*, which cannot be palæontologically
The canines are developed into tusks (fig. 1192),
hey are small in the earlier species. The crowns of
true molars are oblong, and both the upper and lower
nolars (fig. 1194) have a third lobe, although its degree

of development varies greatly; and these teeth do not com use until the first molar has been well worn. The anterio molars are compressed, and there is no diastema between th and the second. The premolars are simpler th true molars, and there i siderable difference in th ber of accessory tuberc veloped in the latter; species in which these a numerous showing a mo plex pattern on the crowns. The molars of the earlier forms approximate to those of ***Hyotherium***.

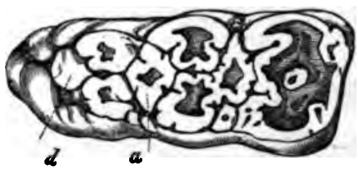


Fig. 1194.—The third right lower true molar of *Sus cristatus*; India. *a, d*, Middle columns of talon.

The species with the most complicated molar structure are *S.* of the Pliocene of the Siwalik Hills, ***S. phacochœroides*** of the Pl Algeria, ***S. karnuliensis*** of the Pleistocene caves of Madras, living Indian *S. cristatus* (fig. 1194), which is also found fos same caves; the last lower true molar of the first-named specie a decided approach to that of ***Phacochœrus***. In the Europe boar, which is found fossil as low down as the Norfolk Forest hind lobe of the last molar is of moderate complexity. ***S. tita*** *giganteus* of the Siwalik Hills of India, together with ***S. an*** *erymanthius*, and *S. major* of the Lower Pliocene of Europe, species with comparatively simple molars; the first being th known species, and fully equal in size to a Tapir. ***S. hysudric*** Siwalik Hills, ***S. palæochœrus*** of the Lower Pliocene of Eppelsh *S. chœroides*, which has been recorded from France and th Miocene of Tuscany, are small species with simple molars like the living *S. andamanensis*, to which they may be allied. *S. ar* of the Upper Pliocene of France is closely related to the living *(Potamochœrus) africanus;* while in the small ***S. punjabiens*** Pliocene of north-western India we probably have the direct a the Pigmy-hog (*S. salvanius*) of the terai-lands of Nipal. No tatives of the genus occur in America; and ***S. chœroides*** seems earliest species.

Here it will be convenient to notice the African W (*Phacochœrus*) which appear to be related to some of the sp fossil species of *Sus*. The dental formula is $I.\ \frac{1}{(2-3)},\ C.\ \frac{1}{1}$ $M.\ \frac{3}{3}$, but the whole of the teeth with the exception of the and the last true molars may be lost in the adult, thus pres very remarkable instance of extreme specialisation. The molar is a very peculiar tooth, consisting of a great numbe agglomerated columns, or denticules; but a marked app this structure is presented in some of the species of ***Sus*** ocene of Algeria and India. Remains of *Phacochœrus* occur in erficial deposits in Africa. The last molar of this genus comed with that of *Hyotherium* presents a difference analogous to at between the corresponding teeth of *Mastodon* and the Mamoth.

We may now revert to the consideration of more generalised pes. The most important is *Hyotherium* (in which may be included *alæochœrus* and *Chœromorus*) which presents characters connecting it with *Dicotyles*, *Sus*, and *Chœropotamus*, and may have been e ancestor of the first wo of these genera. The pper true molars (fig. 195) have low, square owns, with a rudimentary fth column, which is fully veloped in *Chœropotamus*; and the last true olar comes into use bere the first is worn. In e third upper true molar ere is no third lobe, and is lobe is small in the rresponding lower tooth; while occasionally the last upper preolar has only a single outer column, as in *Chœropotamus*. The nines are scarcely larger than the incisors; are oval in section, d the lower one is not received into a notch in the upper jaw. e lateral metapodials are stouter than in modern pigs. In Europe is genus ranges from the Quercy Phosphorites to the Middle iocene of the Continent; while in India it occurs in the Lower waliks of Sind, and also in Perim Island (fig. 1195); the American rms which have been referred to this genus are regarded by Prossor Cope as distinct. *Hippohyus*, of the Indian Siwaliks, appears be an allied but specialised form, in which the crowns of the olars are much taller, and have lateral infoldings of the enamel, hereby an extremely complex pattern is produced on their worn rfaces. *Sanitherium* of the Siwaliks must be placed with this oup; while *Doliochœrus* of the Quercy Phosphorites is apparently lied to *Hyotherium*, although it may also have affinity with *Cebochœrus*. The genus *Babirusa*, of Celebes, is unknown in a fossil ate.


m. 1. *m.* 2. *m.* 3.

Fig. 1195.—The left upper true molars of *Hyotherium perimense*; from the Pliocene of India.

In the John Day Miocene of the United States there occur pigke animals apparently connecting *Hyotherium* with the existing eccaries, most of which may be included in the genus *Chœnohyus*. hese forms agree with *Hyotherium* in having the fourth upper preolar simpler than the true molars, but have the lower canine with

a triangular section, and received into a notch in the upper ja
in the Peccaries. The typical forms have only three premolars,
in others, which it has been proposed to separate generically
Bothrolabis, there are four of these teeth. Allied, or probably i
tical forms have been described as *Thinohyus* and *Perchœrus*,
former having four premolars. The existing South American g
Dicotyles includes the well-known Peccaries, and has the de
formula $I. \frac{2}{3}, C. \frac{1}{1}, Pm. \frac{3}{3}, M. \frac{3}{3}$. The structure of the
canines has been already mentioned; the last upper premolar h
four columns like the true molars (fig. 1196); while the third up

Fig. 1196.—Grinding surface of the right upper cheek-teeth of a Peccary (*Dicotyles labiatus*). (After Giebel.)

true molar, which comes into use before the first is worn, has
distinct third lobe. In the pes the phalangeals of the fifth digit a
aborted. Remains of two existing and one much larger exti
species of this specialised genus are found in the Pleistocene
posits of the Brazilian caves; while large Peccaries also occur
the Pliocene of the United States and the Pleistocene of Mexi
which have been described as *Platygonus*, but may be includ
in the type genus, although they have rather simpler premolars.

FAMILY CHŒROPOTAMIDÆ.—The true molars of this exti
family are intermediate in structure between those of the *Suidæ* a
Anthracotheriidæ; having in the upper jaw very broad and sh
crowns, which carry five columns arranged as in the latter fami
The premolars, although somewhat compressed, are not secant, a
may be of very large size. In the two best known European gen
there is a diastema between the first and second upper premola
The mandible has no descending flange at the angle.

One of the most pig-like members of this family is the gen
Cebochœrus, comprising animals of the size of *Hyotherium*, whi
have been considered by some as allied to the *Lemuridæ*, althou
there is little doubt that their true relationships are with the prese
group. They apparently possessed the full typical number of teet
which (especially in the lower jaw) present a great resemblance
those of *Hyotherium;* and it is highly probable that they are close
related to the ancestor of that genus. *Cebochœrus* is represented
several species in the Upper Eocene of France; but the form

n the Middle Miocene of Bavaria may be generically dis-
ied to this genus are *Hemichœrus* of the Quercy Phos-
ıd *Leptochœrus* of the North American Miocene, in which
lars have a very simple structure. All these forms, to-
the following genus, are placed by some writers with the
he type genus *Chœropotamus* occurs in the Upper Eocene
and England, and has been erroneously stated also to
e Miocene of Bavaria. The upper true molars resemble
rtain species of *Anthracotherium*, but have shorter crowns,
approach to a selenodont structure. There is a third
ıe last lower true molar, and the dental formula is
Pm. $\frac{4}{3}$, *M.* $\frac{3}{3}$. The feet are unknown, but it is probable
were furnished with four digits. The type species *C.*
f the Paris gypsum, was an animal of the size of a large
is probable that this genus is a survivor of a form which
mmon ancestor of both the *Suidæ* and the *Anthracothe-*
otherium, which has been also described under the names
m, *Archæotherium*, *Oltinotherium*, and *Pelonax*, is a larger
in many dental characters to *Chœropotamus;* and is one
few members of this suborder in which the last lower
has no third lobe. The premolars are relatively large
; the canines recall those of some of the Carnivora; and
nal digits of the feet are reduced to two. The dental
the typical one; and the genus is placed by some writers
ıthracotheriidæ. Its remains are found in the Upper
osphorites of Quercy, in the Lower Miocene of Ronzon,
and of Hempstead in the Isle of Wight, and also in the
f North America. Apparently allied to this genus is
on of the Pliocene of the Indian Siwalik Hills, in which
ver molar has a third lobe, and the conical premolars are
us size. In this neighbourhood must probably also be
remarkable North American Eocene genus *Achænodon*
dentical with *Parahyus*) which has, however, been con-
Professor Cope as allied to the Lemuroidea and Insecti-
e structure of the teeth is like that obtaining in the pre-
, and the last lower molar has a third lobe, but the first
s wanting in both jaws. The skull presents, however,
nivorous features, and it is possible that this genus should
placed among the bunodont Condylarthra in the neigh-
of *Periptychus.* The resemblance presented by the teeth
r to those of *Elotherium* and *Achænodon* is, indeed, so re-
as to suggest that those two genera may be descendants
ıknown member of the Condylarthra very closely allied to
ychidæ.

FAMILY ANTHRACOTHERIIDÆ.—In this family the dental forn is, with one exception, $I.\ \frac{3}{3},\ C.\ \frac{1}{1},\ Pm.\ \frac{4}{4},\ M.\ \frac{3}{3}$; the upper molars (fig. 1199) have broad, low crowns, with five columns, t of which are situated on the anterior and two on the posterior l the columns in both upper and lower molars have a more or distinctly selenodont structure; and the mandible has a desc ing flange at the angle. The Anthracotheres were probabl appearance somewhat between a Pig and a Hippopotamus, doubtless dwelt in swamps and marshes. In the type genus *thracotherium* (fig. 1197) the selenodont structure of the teet less marked than in the next genus, with which it agrees in ha four digits to each foot.

The species which approaches nearest to *Chœropotamus* in the stru of its molars is the small *A. silistrense* of the lower Siwaliks of I but the still smaller *A. Gresslyi* (fig. 1197) from the Upper Eoce Switzerland and Hampshire, agrees with that genus in having a dias

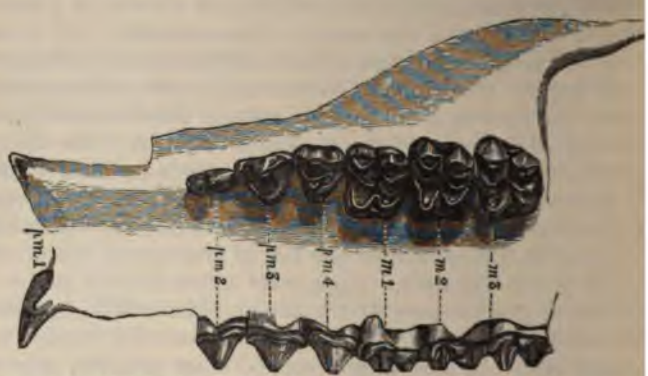


Fig. 1197.—*Anthracotherium Gresslyi*. The left half of the palate and the upper ch dentition; from the Upper Eocene of Hordwell, Hampshire.

between the first and second upper premolars, and in the absence first lower premolar. In most of the other species all the cheek-teetl in contact. This genus commenced in the Middle Eocene of Pr in Dalmatia, where it is represented by *A. dalmatinum*, which has made the type of the genus *Prominatherium*; it was abundant i Quercy Phosphorites and Lower Miocene of Europe, where it w presented by species like *A. magnum*, *A. valdense* of Lausanne, ar *illyricum* of Tuscany, which attained the size of a Rhinoceros. I represented in the Middle Miocene of France by *A. Cuvieri*, after it died out in Europe, although it survived in India till the Upper cene, where it is known by the large *A. hyopotamoides* and the sm *silistrense*. It is unknown in America.

genus *Hyopotamus* generally has a more completely seleno-
ntition than *Anthracotherium*, but in some species (fig. 1198)
haracters are less marked, and thus indicate a complete
on between the two genera. In those species (fig. 1199)
have the most perfectly selenodont dentition the columns of

. 1198.—The third left upper true of *Hyopotamus giganteus*. Up-liocene, India.

Fig. 1199.—The third right upper true molar of *Hyopotamus bovinus*. Lower Miocene, Isle of Wight.

e molars are taller than in the others. The first upper pre-
is separated by an interval both from the canine and the
premolar. This genus apparently commenced in the Upper
of Europe, and is especially characteristic of the Hempstead
the Isle of Wight, and of the Ronzon beds of France, where
presented by the large *H. bovinus* (fig. 1199), *H. velaunus*,
e brachydont *H. porcinus*. In India it survived till the
Miocene, where it is represented by two species, one of
fig. 1198) is the largest known form; it
curs in the Miocene of North America.
ame *Diplopus* has been applied to
from the Upper Eocene of Hamp-
ith only two digits to each foot, which
en referred to this family; since, how-
s dentition is unknown this determina-
only provisional, and it has been sug-
that it may be a *Dichodon*, although it
too large for the type species.

Fig. 1200.—A right upper true molar of *Merycopotamus dissimilis*; from the Pliocene of India.

ILY MERYCOPOTAMIDÆ.—This family
regarded as an offshoot from the *An-
heriidæ* in which the upper true molars (fig. 1200) have only
olumns on their crowns; the dental formula being the same.
robable that the feet were tetradactylate; and the mandible

has a descending flange. Some writers include this family in *Anthracotheriidæ*, and perhaps this is really the better arrange The type genus is found only in the Pliocene Siwaliks of I and Burma, where it is represented by *M. dissimilis* (fig. 1 and two smaller species. An imperfectly known but closely form from the Upper Miocene of Sind has been described u the name of *Hemimeryx*. In this and all the preceding families odontoid process of the axis vertebra is peg-shaped.

FAMILY COTYLOPIDÆ.—This extinct North American fami usually known as the *Oreodontidæ*,[1] is regarded by Professor Co as related to the *Anoplotheriidæ*, but with more completely sele dont teeth and less specialised feet, which are more like those the Hippopotamus than those of the Ruminants; but their affiniti are probably widely spread. Upper incisors are present; the tr molars (fig. 1201) are selenodont, and those of the upper j usually have only four columns on their crowns; and the p

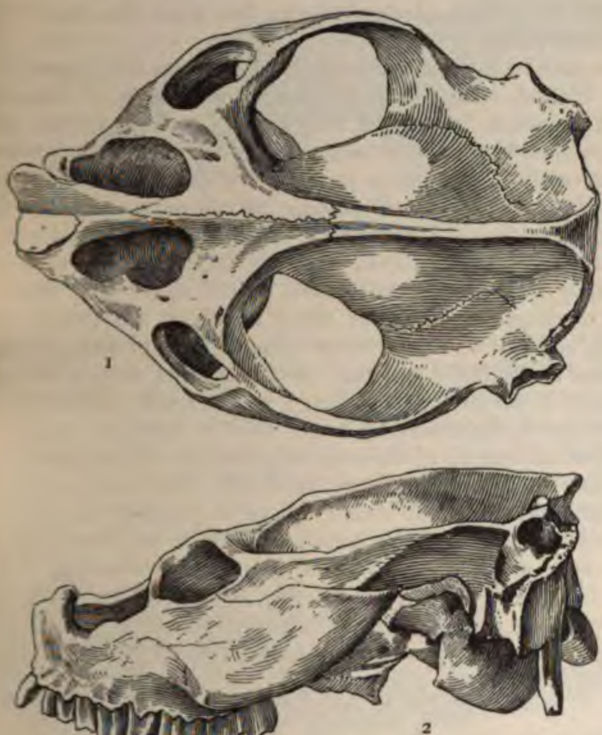
Fig. 1201.—Oral surface of the right upper cheek-teeth of *Eporeodon major*. Miocene, North America.

molars are simpler than the true molars, but are not secant lower canine is approximated to the incisors, and its functio taken by the first premolar, which has a tall crown biting bel the upper canine. The ulna, radius, tibia, fibula, metapod navicular, and cuboid are all distinct; and each foot carries digits. The odontoid process of the axis vertebra is interme in shape between the peg of the Bunodonts and the half-cylind the Ruminants; the lachrymal bone frequently has a deep *lar* depression; but the angle of the mandible has no descending fla

In the type genus *Cotylops* (*Oreodon*) the dentition is $I. \frac{3}{3}$, ($Pm. \frac{4}{4}$, $M. \frac{3}{3}$; the orbits are completely surrounded by bone premaxillæ are separate, the auditory bullæ not inflated; there no vacuities in the bones of the face; and there is a small poll

[1] The name *Oreodon* being preoccupied by *Orodus* (*supra*, p. 940), inv the change of the family name. *Cotylops* was originally applied by Leidy to species of the type genus.

manus. In *Eporeodon*, or *Eucrotaphus*, the above characters the same, with the exception that the tympanic bullæ are in-d; while *Merycochœrus* differs from the latter by the anchylosis he premaxillæ. There are seven species in the latter genus. ychyus is distinguished from *Merycochœrus* by the presence acuities in the lachrymal region. In *Leptauchenia*, which has n placed by some writers in the *Camelidæ*, such vacuities occur



g. 1202.—Frontal (1) and left lateral (2) aspects of the cranium of *Cyclopidius emidinus*; from the Miocene of the United States. Reduced. (After Cope.)

e to the frontals, and the nasals become very small. Still more arkable is the enormous development of these vacuities in *Cyclo-us* (fig. 1202), in which the upper incisors are wanting. *Pithecistes*, n, differs from all the preceding by the absence of the first pre-ar, and has but one pair of lower incisors. In the second divi-n of this family, which includes the genera *Agriochœrus* and *oreodon*, the orbit is incompletely surrounded by bone, and the fourth upper premolar has two outer columns in place of th one of the typical section (fig. 1201). *Coloreodon* diffe *Agriochærus* by having only three premolars, but it may b tioned whether this difference really affords sufficient grou generic distinction. The majority of the genera are conf the White River Miocene of North America, but *Mery* extends into the Loup-Fork beds, which may be either of Miocene or Lower Pliocene age. A tooth, apparently indist able from the molars of *Agriochærus*, has been obtained fi Pliocene of India.

Here may be noticed a remarkable form from the Upper of the United States, described under the name of *Pro* The organisation is said to be of the Cotylopine type, upper molars have five columns, as in the *Anthracotheri* *Anoplotheriidæ*. This genus probably indicates an ancestra the *Cotylopidæ*, which should perhaps be referred to a distinc it is, however, placed by Professor Cope near the Xiphodon

FAMILY ANOPLOTHERIIDÆ.—In this family the cheek-t imperfectly selenodont; the crowns of the upper true mo 1204) carrying five columns, three of which are placed anterior, and two on the posterior lobe, or half, of the crow the bones of the limbs and feet remain distinct from one and there is no descending flange at the angle of the n The functional digits may be either two or three in numb the carpus and tarsus of the original genus are of that type the name inadaptive has been applied.[1] The anterior p are more or less perfectly secant; there is generally no dia the dental series; and the canines are short and compres depart very widely from those of the *Anthracotheriidæ* a allies, in which they resemble the corresponding teeth Carnivora. In the type genus *Anoplotherium* (in which included *Eurytherium* and *Diplobune*) the dentition (fig. usually $I.\ \frac{3}{3},\ C.\ \frac{1}{1},\ Pm.\ \frac{4}{4},\ M.\ \frac{3}{3}$; but occasionally the fi premolar is wanting. The tail (fig. 1203) is long; the fi digits may be either three or two;[2] and the third upper pren a well-developed inner tubercle. In the typical *A. commun*

[1] In the inadaptive modification (*Anoplotherium*) the carpals of th digits remain as useless lateral bones; while in the adaptive m (*Hyotherium*) they shift their position, and take a share in the supp large persistent digits.

[2] Prof. Cope has suggested that the forms with two digits should be from this family, but it is the type species which presents this feature. with three functional digits is indistinguishable by dental characters typical *A. commune* with only two.

s gypsum, the columns of the cheek-teeth are comparatively but in other species, like *A. cayluxense* of the Quercy Phosites (fig. 1204), they are shorter, and the teeth thus approxi- to those of the brachydont species of *Hyopotamus*. This s is confined to Europe, and is characteristic of the Upper ene (Lower Oligocene) and the Miocene of Ronzon in Puy-en-

. 1203.—Skeleton of *Anoplotherium commune*; Upper Eocene, Europe. Much reduced

ay. The species from the South American Tertiaries originally rred to this genus is now known as *Proterotherium*, and is ced under the Perissodactyla. The largest species was about size of a Tapir. Here may be noticed five genera from the rcy Phosphorites, some of which appear, on the whole, to be t nearly allied to *Anoplotherium*, although their teeth present ain resemblances to those of the Perissodactyla, in which suber the last of the group is placed by some writers. Of these

Fig. 1204.—The last five right upper cheek-teeth of *Anoplotherium cayluxense*; from the Upper Eocene of France.

ra *Adeotherium* is characterised by the extreme complexity of last upper premolar, which resembles the first true molar; *riotherium* is only known by the mandible, in which the pre- rs are simpler than in the type genus; and the true molars some resemblance to those of *Lophiomeryx*; *Mixtotherium*, ch is described from the palate, and is probably identical with the preceding, also has simple premolars; *Myxochærus* sh completely selenodont teeth; while those of *Tapirulus* app to the molars of the *Tapiridæ*. In another direction *Dacrytherium* and *Plesidacrytherium*, from the Upper Ec France and England, in the former of which the first upper of either side are separated from one another by a wide while the first three premolars are more completely secant the type genus. The dental type of *Dacrytherium* leads o to that of *Xiphodon*, which, in accordance with the views fessor Rütimeyer, is therefore placed in the same family, some writers make it the type of another family, which is include either *Cænotherium* (Fl *Dichodon* (Schlosser). The tru are like those of the type genus *therium*, although more complete dont; but the first three premo 1205) are much elongated a pressed; and the functional di reduced to two in each foot. typical forms there was no dia the dental series (which comprises the full typical numbe certain smaller forms, separated by some writers under the *Xiphodontotherium*, a distinct diastema was developed. T donts were animals of slender build, with limb-bones sembling those of *Anoplotherium*, and partly those of specialised Selenodonts; they are characteristic of t Eocene of England and the Continent, the largest spe *X. magnus*, and the smallest *X.* (*Xiphodontotherium*) *se* of the Quercy Phosphorites. This genus, although not in line, shows how a transition can be effected from the highe *cotheriidæ* to the *Dichodontidæ*. *Rhagatherium*, from t Eocene of Switzerland, is an allied genus. Finally, Dr refers to this family the genus *Brachytherium*, from the South America; while Dr Schlosser would include in it *Tetraselonodon*, founded on teeth from the Quercy Ph which have only four columns on the crown.

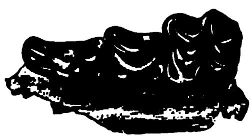


Fig. 1205.—The last two left upper premolars and first true molar of *Xiphodon gracilis*; from the Upper Eocene of Hampshire.

FAMILY CÆNOTHERIIDÆ.—Following the classificatio fessor Rütimeyer the next family we have to consider which the type genus is *Cænotherium*. All the genera ha complement of teeth, and there are usually five columns, on the crowns of the upper true molars (which may be eit dont or bunodont); two of these columns being plac anterior and three on the posterior lobe of the teeth, thus the arrangement obtaining in the *Anoplotheriidæ*. The *Cænotherium* comprises a number of species of small a r than a Rabbit, in which the teeth are selenodont; the ante-premolars more or less secant; the auditory bullæ inflated (fig.) and the feet furnished with four complete digits. These animals probably approximated in outward appearance to the g Chevrotains (*Tragulus*) of the Oriental region. In the typical s there is no diastema in the dental series; but this is present her species to which the name *Plesiomeryx* has been assigned

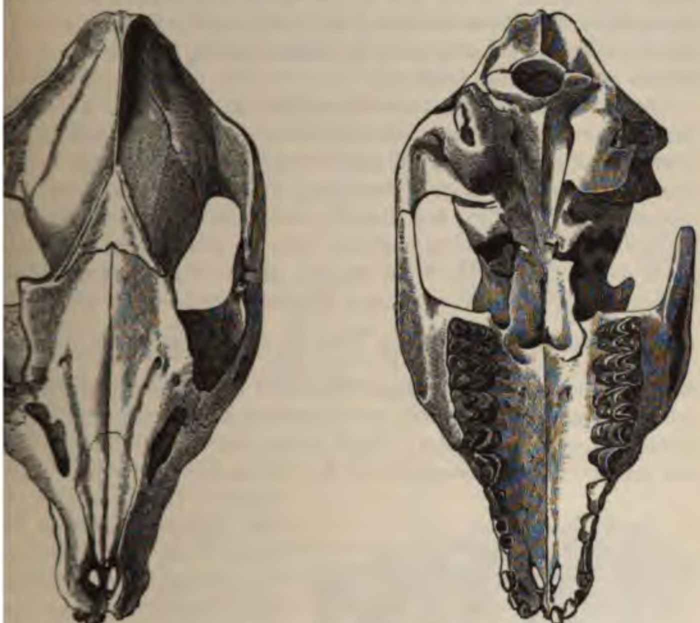


Fig. 1206.—*Cænotherium Filholi.* Upper and lower views of the cranium; from the Upper Eocene of Caylux.

me writers. The limb-bones show characters connecting them with the *Suidæ* and the Ruminants. In the figured cranium asals are peculiar for terminating in a point. This genus, of h the names *Zooligus* and *Microtherium* are also synonyms, s from the Upper Eocene (Lower Oligocene) of Vaucluse to Lower Miocene (Upper Oligocene) of Allier. An allied genus *ouillactherium*, of the Quercy Phosphorites, in which the third r true molar has but four columns; while yet another allied from the same deposits has received the name *Oxacron*. The pean Upper Eocene genus *Dichobunus* (*Didymodon*) is regarded rofessor Rütimeyer as a bunodont form closely allied to *Cæno-um; Dilotherium* and *Spaniotherium* being kindred genera from the Quercy Phosphorites. The limb-bones, althougl four digits are developed, show considerable resemblances to the Ruminants, and it has been thought that *Dichobunus* ı been the direct ancestor of *Gelocus*. Here also may be m the peculiar Upper Eocene European genus *Acotherulum*, the general form of the skull and teeth of the one know seems to indicate affinity with *Dichobunus*, while the absen third cusp on the hinder lobe of the upper true molars, and completely bunodont structure of these teeth apparently affinity with *Cebochœrus* and its allies, among which son prefer to place this genus.

FAMILY DICHODONTIDÆ.—According to the views of Rütimeyer this family is taken to include several genera witl dont dentition in which the upper true molars have four the type genus *Dichodon* presenting affinities with *Xipho* *Gelocus* and its allies are closely related to the *Tragulid* *Cervidæ*. Other writers, however, who do not attach suc ance to the structure of the molars, place *Dichodon* with and make *Gelocus* the type of a distinct family.[1] In *Di* dental formula is $I.\ \frac{3}{3},\ C.\ \frac{1}{1},\ Pm.\ \frac{4}{4},\ M.\ \frac{3}{3}$; the upper t having concave outer surfaces somewhat like those of *H* while the earlier premolars are elongated and secant, an proach those of *Xiphodon;* there is no diastema. The l are unknown, but it is probable that there were only two digits. This genus the Upper Eocene shire. In *Lophio* 1207) from the Upp and Lower Mioce Continent, the hir crescent of the u molars is imperfect ed, and the first lc lower true molars that of *Anoplotherium*, while the second is Ruminant-li lower molars also resemble those of *Metriotherium* (p. ı the family position of this genus, which is referred by I to the *Tragulidæ*, is still doubtful. *L. Gaudryi* from tl Phosphorites has been made the type of the genus *Cr* In *Gelocus*, from the Quercy Phosphorites and Lower M Puy-en-Velay, it is not known whether upper incisors wer

Fig. 1207.—The last four right upper cheek-teeth of *Lophiomeryx Chalaniati;* from the Quercy Phosphorites.

[1] Prof. Cope would include in this family the type genus and th *Agriochœrus* and *Coloreodon*.

the upper molars have low columns, with wide and open ys, the external surface of each lobe resembling that of *Dich-* The navicular and cuboid bones of the tarsus were united, the metatarsals fused into a cannon-bone, although the meta- ls were distinct. Allied to this genus are *Phaneromeryx* *Protomeryx* of the Upper Eocene of France; while *Chæro-* r of the Siwaliks of India may be provisionally referred to this y.

MILY TRAGULIDÆ.—The fossil forms included in this family te a transition from the typical genus on the one hand to the *dontidæ*, and on the other to the *Cervidæ*. The upper true s have four columns, and the earlier premolars are more or less letely secant. None of the genera were furnished with antlers, is probable that upper incisors were likewise always absent. e existing forms pper canines of the (fig. 1208) are in ape of tusks; there long diastema in jaws; the third ch, or 'psalterium,' ting; and the pla- is diffuse. The ave supplementary and the metacar- of the third and

Fig. 1208.—Reduced side view of the skull of *Tragulus javanicus*.

digits either unite late in life to form a cannon-bone, or re- (as in *Hyomoschus*) permanently separate. *Bachitherium* of uercy Phosphorites, in which there are three premolars in each hows resemblances both with *Gelocus*, *Hyomoschus*, and *Pro- therium;* the upper teeth being very similar to those of the In *Dorcatherium*, with which the existing *Hyomoschus* of appears generically identical, the premolars are $\frac{3}{(3-4)}$, and are ecant type, and thus indicate affinity with the *Dichodontidæ;* enus is found in the Middle Miocene and Lower Pliocene of ontinent, and also in the Pliocene of India. *Tragulus*, which s by the fusion of its metapodials into cannon-bones, and by having more than three lower premolars, is now confined to riental region, and is represented by one species in the Plio- of India. *Leptomeryx*, from the Miocene of North America, our premolars, of which the first three are simply secant as in *ulus*, while the fourth has an inner tubercle; there are four ate metacarpals, but the third and fourth metatarsals form a on-bone, as in *Gelocus*. In *Prodremotherium*, of the Quercy

Phosphorites, the dentition is almost, if not quite, indisting from that of *Leptomeryx*, but cannon-bones are found in bot although the union of the factors in the anterior ones is less c than in the others. These two genera apparently connect G completely with the cervine *Palæomeryx*, that we can have tation in regarding them as representing the direct line descent of the *Cervidæ* from the *Dichodontidæ*; while we n sider the existing *Tragulidæ* as lateral offshoots from son allied primitive stock. *Hypertragulus*, from the Miocene America, appears to be a form closely allied to *Leptomeryx*, the metatarsals separate.

FAMILY POËBROTHERIIDÆ.—We must here leave for a s the connection between the *Tragulidæ* and the *Cervidæ*, to the Camels and their allies, whose nearest existing relatio be found in the former family. The *Poëbrotheriidæ* are re typically by the genus *Poëbrotherium*, of the North Ameri cene, in which the dental formula is $I. \frac{3}{3}, C. \frac{1}{1}, Pm. \frac{4}{4}, M.$ structure of the cheek-teeth is selenodont; in the feet the fourth metacarpals remain distinct, the second and third b mentary; the carpus has a trapezium; and the navicular ar are not fused together. The structure of the cervical ve the same as in the *Camelidæ*, of which this family may be as the ancestral type; but in other respects there are affinity with the *Tragulidæ*. The type species of *Poëbrothe* scarcely larger than a Fox. In the John Day Miocene o an allied form has received the name of *Gomphotheriu* *Leptotragulus* of the Upper Eocene of the United States the ancestral form of both the Miocene genera.

FAMILY CAMELIDÆ.—In the Camels the cheek-teeth ar dont and quadricolumnar, but of somewhat simpler struct those of the following families. The navicular and cuboi distinct, but the metapodials unite to form a cannon-b least one pair of upper incisors is present; and in the cervi bræ the arterial canal passes obliquely through the anteric the pedicle of the neural arch, and is thus confluent posteri the neural canal; a similar condition prevailing in *Mac* among the Perissodactyla. At the present day this family sented by *Camelus* of the Old, and *Auchenia* of the New but it appears to have originated in the latter, where a large of forms have been found. The most generalised me *Protolabis*, of the Miocene of the United States, in which t tion is numerically the same as in *Poëbrotherium*, on which Professor Cope makes it the type of a distinct family. *camelus* (fig. 1210, B, C) of the Lower Pliocene or Upper the same area, the incisors were reduced (as in all the other forms) $\frac{1}{3}$, but there were still four premolars, although the first is isolated nd the second very small. *Pliauchenia* (which is perhaps identical ith *Homocamelus*) has only three lower premolars, and occurs in the

Fig. 1209.—Left lateral view of the skull of the Camel (*Camelus bactrianus*). Reduced. Upper incisor; *c*, *c*, Canines; *pm*, Isolated premolar. The maxillo-premaxillary suture should ve been placed in front of *c* instead of in front of *pm*.

oup-Fork-beds of North America. In *Camelus* again (fig. 1209) e normal adult formula of the cheek-teeth is *Pm.* $\frac{2}{3}$, *M.* $\frac{3}{3}$; the rst upper premolar being canine-like, and separated by a long terval from the penultimate tooth of that series. This genus is nfined to the Old World; the earliest known species occurring in e Pliocene of India, and another form (*C. Thomasi*) in the Pleisto-ene of Algeria. The molars of the Siwalik species show characters ow only found in *Auchenia*. The latter generic term is here taken

Fig. 1210.—A, First left lower true molar of *Auchenia hesterna*, Pleistocene, California: B, ourth right upper premolar and first true molar of *Procamelus virginiensis*, Miocene, North merica; C, Third right lower true molar of do.

o include a number of fossil New World forms some of which ave been generically separated under the names of *Hemiauchenia*, *'ulauchenia*, *Protauchenia*, *Holomeniscus*, and *Eschatius*. In the existing species, which occur fossil in the caves of Brazil, th molars are normally $\frac{2}{2}$ in number, but there is often but these teeth in the lower jaw; in *A.* (*Palauchenia*) *magna* fro Pleistocene of Mexico, there were always two and occasionally lower premolars; while in a Pleistocene South American (*Hemiauchenia*) there were three premolars in both jaws. (*Holomeniscus*) *hesterna* (fig. 1210, A), from the Pleistocene of America, on the other hand, the premolars were reduced to each jaw; while *A.* (*Esc vitakeriana* has the same ber, but is distinguished simpler nature of the upp The majority of the speci of comparatively small si *A. magna* and *A. hestern* equal in bulk to the Ca the present day.

Fig. 1211.—A, Dorsal aspect of the right manus of Ox (*Bos taurus*); B, Do. of right pes of Red-Deer (*Cervus elaphus*). Reduced. *ca*, Carpus; *ta*, Tarsus; *c*, Metapodium (cannon-bone).

FAMILY CERVIDÆ.—T ent and three following of the suborder coll constitute the Pecora cent Zoology;—a gro defined at the prese but, as already me connected in past epoc intimately by this fam the *Tragulidæ*. The d of the entire group is $I. \frac{0}{3}, C. \frac{(0-1)}{1}, Pm. \frac{3}{3},$ upper incisors being in absent. The true mo perfectly selenodont, a upper ones carry four c the second premolar is in contact with the third is a long interval, or d between the lower pr and canine; and the approximated to, and resembles the incisors third and fourth metapodials (fig. 1211) coalesce into a bone; the navicular and cuboid of the tarsus are likewise and the odontoid process of the axis vertebra forms a sp

-cylinder. Moreover, in all existing members of this group lateral metapodials are either incomplete or totally wanting 1211); the stomach is composed of four complete cavities; the placenta develops structures known as cotyledons. On the l either horns or antlers are very generally present, at least in males of recent forms.

n the *Cervidæ* upper canines are generally present, although a few exceptions they are of comparatively small size; the ek-teeth, and more especially in the earlier forms, are very erally of a more or less brachydont structure, the first true ar being invariably of this type; and the upper premolars ays have both an inner and an outer column, and are er simply secant like those of the existing *Tragulidæ*. In skull there is always a large vacuity in front of the lachry- which prevents that bone from articulating with the nasal. a large number of forms antlers are present in the male, in *Rangifer* also in the female. Antlers, it may be ob- ed, are outgrowths of true bone arising from the frontal

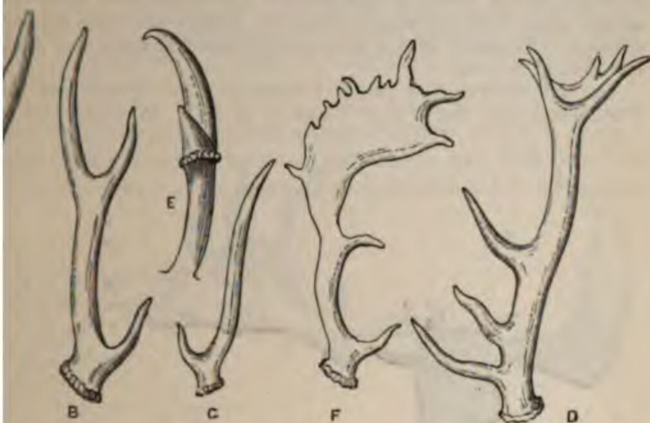
g. 1212.—Reduced left lateral aspect of the skull of the Roebuck (*Capreolus caprea*).

n of the skull (fig. 1212), which during their development nvested with a vascular, hairy skin. On the completion of growth a constriction of the blood-vessels near their base is ly brought about by the formation of a *burr*, and above point the skin peels off and leaves the bone bare and in- ble; after a time the antler is shed, leaving a more or less gated pedicle attached to the skull, from which a new antler eveloped. In young animals the antlers are simple, and in e species in which they finally attain a great complexity, this quired gradually in successive annual growths. Each antler ys consists of a main stem or *beam*, and usually of one or more ches or *tines;* of which the one immediately above the burr is termed the *brow*-tine. The lateral digits are nearly present, and the distal extremities of the metapodials may served. The existing Deer have been divided into the Ple carpalia (*Cervus* and *Cervulus*), and the Telemetacarpalia *Capreolus*, *Cariacus*, and *Rangifer*); the former, which m habit the Old World, characterised by the retention of the p and the latter of the distal extremities of the lateral met As in many analogous instances, the development of the a the individual is paralleled by their development in the since we find that many of the earlier members were to provided with these appendages, and that their extreme co in the more specialised forms was not acquired until a la in the geological scale.

The least specialised members of this family form th allied extinct genera *Amphitragulus* and *Palæomeryx*. In tl there are four lower premolars, and antlers were entirely ab crowns of the molars being low. The largest species was s bigger than the Musk-Deer, and the genus is characterist Lower Miocene of the Continent. *Palæomeryx* (*Drem Dicroceros*, and *Micromeryx* being included) has only th premolars, except in one species; and the upper true m 1213), like those of *Amphitragulus*, were brachydont, an distinct accessory column between t crescents. In one species (*P. Feign* lateral metacarpals were perfect, altho slender, and the males had long uppe like those of the Musk-Deer, but no this species being the earliest, and in the Lower Miocene of France. I *catus* (*Dicroceros elegans*), of the Mic cene, simple antlers were, however, and the canines were apparently sn *Bojani*, of the French Middle Mioc *P. sivalensis* (fig. 1213), of the Pl India, were as large as a Red Deer; and the latter species, with another from the Pliocene of China, were the last re tives of the genus, of which the latest appearance in Eu the Middle Miocene of Sansan, in France. *Platyprosopus*, latter beds, is distinguished by the great projection of the the mandible. To the existing Oriental genus *Cervulus*, the molars are more hypsodont, and simple antlers mour long pedicle are present, may be provisionally referred *C. ceros* (fig. 1214, A), of the Pliocene of Eppelsheim. There uncertainty as to the earliest appearance of the genus *Cerv* not improbably dates from the Middle Miocene, and was a

Fig. 1213. — Left upper true molar of *Palæomeryx sivalensis*. Pliocene, India.

ower Pliocene; at the present day it ranges throughout the ic region, but is unknown in the Ethiopian region and the art of America. This genus, as we have already observed, to the Plesiometacarpalian section; the antlers may be of



—A, Antler of *Cervulus* (?) *dicranoceros*—Pliocene; B, Antler of *Cervus pardinensis* C, Antler of the Red Deer (*Cervus elaphus*) in the second year; D, Antler of the lly-grown condition; E, Antler and bony pedicle of the frontal bone of the Muntjak *untjak*); F, Antler of the Fallow Deer (*Cervus dama*).

complexity; and the hinder molars are either brachy- or t, there being frequently an inner accessory column in the e molars.

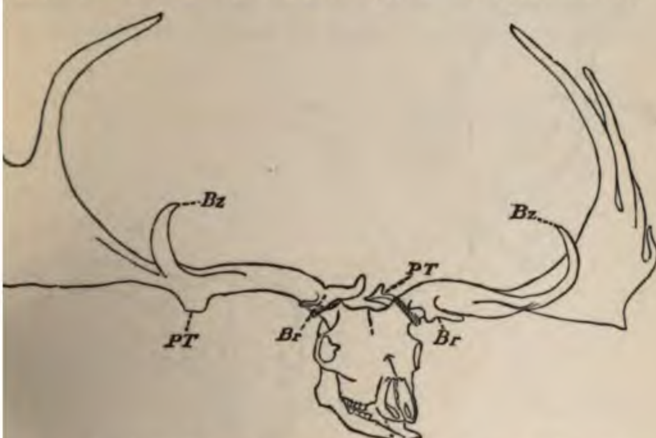
nus is divided into a number of groups, of which the distribution be briefly noticed. The most aberrant is the *Tetracerotine* med by *Cervus tetraceros* of the French Pliocene, in which the pproximate to those of *Cariacus*. The *Axine* group, now con- he Oriental region, in which the molars are more hypsodont l, and the antlers are rounded and comparatively simple, is ed by several species, such as *C. pardinensis* (fig. 1214, B), in the of Europe, while the living *C. axis* occurs in the Pleistocene of The Oriental *Rucervine* group has a representative in *C. siva-* the Pliocene of India; while the allied *Rusine* group, of the ion, in which the antlers are still comparatively simple, and beam often strongly grooved, is known in a fossil state by the f existing species from the Pleistocene of India. In the *Ela-* up, which includes the Canadian Wapiti (*C. canadensis*), the Red *elaphus*) of Europe and North Africa, together with some large om the Palæarctic region, the antlers (fig. 1214, C, D), although led, are often cupped at their summits, and carry a second, e, immediately above the brow-tine. In this group remains o the existing Red Deer (*C. elaphus*) are of common occurrence istocene of Europe. Some of the fossil antlers and jaws indi- ever, much larger animals than any Red Deer now existing, and it has been suggested that these remains belong either to *Cervus maral* of Persia, or to the Wapiti (*C. canadensis*) of North America. Both these forms are, however, closely allied to the Red Deer, and it appears preferable to regard all the European fossils as referable to a single species from which the three existing types are derived. There is, however, the name *C. spelæus* for the large fossil form (which is of earlier date than the name *C. maral*), if that be really distinct from *C. elaphus*. Remains of the Wapiti are recorded from the Pleistocene of the United States.

The *Eucladocerotine* group comprises *C. Sedgwicki* of the Norfolk Forest-bed and the Upper Pliocene of Italy, in which the antlers a

Fig. 1215.—Skeleton of the Irish Deer (*Cervus giganteus*); from the Pleistocene of Irel
Greatly reduced. (After Owen.)

more complex than in any other species. In the *Damine* group antlers (fig. 1214, F) have their terminations palmated, and the brow simple; the existing Fallow-Deer (*C. dama*) occurs in the bone-cav Gibraltar, while allied forms are found in the English Forest-bed Crag; the most noteworthy being *C. verticornis*, in which the brow t sharply downwards. The last group which it is necessary to on here is the *Megacerotinæ*, which contains only the Irish Deer *s giganteus*, fig. 1215), characterised by its enormous palmated (fig. 1216), which diverge at right angles from the plane of the , and have a distinct brow- (*Br*) and bez- (*Bz*) tine, and a small or tine (*PT*) on the opposite side of the beam to the bez-tine. s of this fine species are found in the Pleistocene of Northern and are especially abundant in the bogs of Ireland, where speci-ave been found with a spread of more than eleven feet between of the antlers.

ig to the Telemetacarpalian genus *Rangifer*, which is at once rised by the peculiar form of the antlers and their presence exes, we find remains of the existing Reindeer (*R. tarandus*),



.—Skull and antlers of *Cervus giganteus*. Reduced. *Br*, Brow-, *Bz*, Bez-, *PT*, Posterior tine. (After Scott.)

fined to the higher latitudes of the Northern Hemisphere, t in the Pleistocene of a large portion of Europe. In *Alces* or Moose (*A. machlis*), of the northern parts of Europe and , occurs in the Pleistocene of the same regions; while an ex-cies has been described from the Norfolk Forest-bed. The fig. 1217) have no bez-, and apparently no brow-tine, but led into an anterior forked branch (*A*) and a posterior pal-ne (*P*). A very remarkable form from the Pleistocene of America, described under the name of *Cervalces*, appears to *Alces* with *Cervus*, although it belongs clearly to the Tele-palian section. Thus the antlers (fig. 1218) are superiorly into an anterior (*A*) and posterior (*P*) branch; but below er there occur two tines (*Bz* and *PT*), which Dr Scott as probably corresponding to the bez- and posterior tines of the Irish Deer. And we may likewise trace an interme type in the vertical height of the skull, and the form and co tions of the nasal and premaxillary bones. In *Capreolus*, whe antlers are simple and rounded, the existing Roe (*C. capre* 1212) occurs in the European Pleistocene; while *C. cusanus*, French Pliocene, is regarded as the ancestor of that specie the peculiar *C. Matheroni*, of the Lower Pliocene of both and France, is provisionally referred to the same genus. *Ca* again, which is peculiar to the New World, and is charac

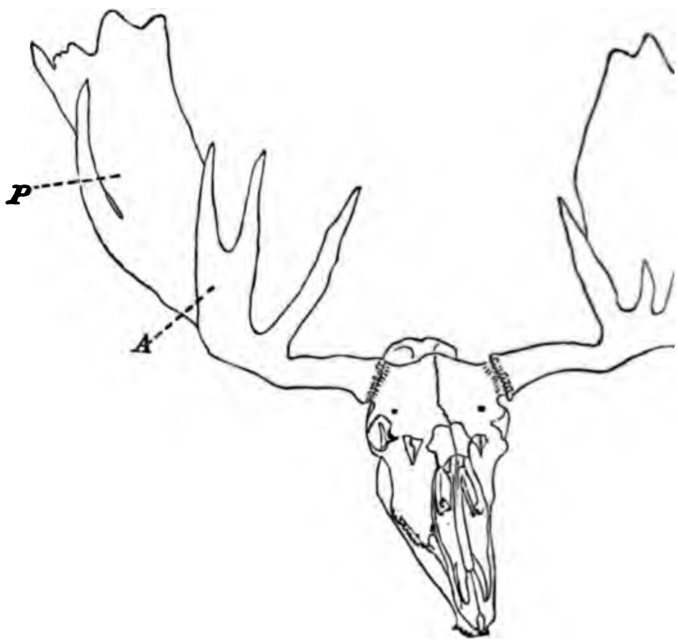


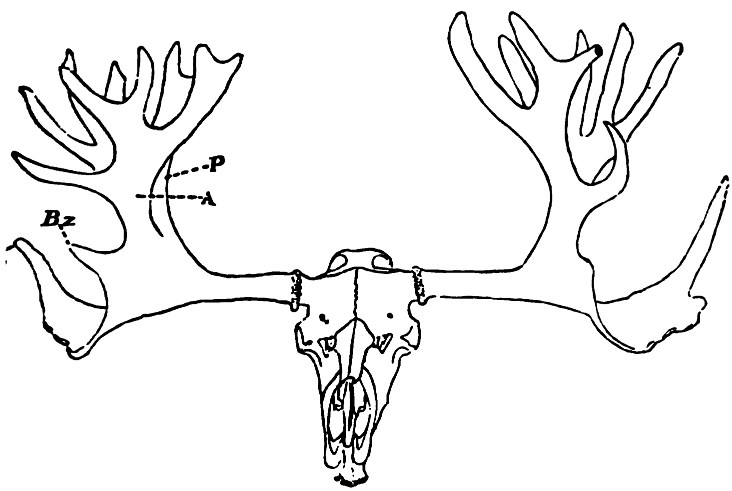
Fig. 1217.—Skull and antlers of the Elk (*Alces machlis.*) Reduced. *A*, Ante *B*, Posterior branch. (After Scott.)

either by very simple prong-like antlers, or by a more compl totally unlike those of any existing European members of the is represented by several existing, and perhaps by some species in the Pleistocene of South America. Lastly, it sh observed that antlered Deer occur in the Tertiaries of America, and the name *Blastomeryx* has been applied to o which is regarded as the ancestor of *Cariacus*.

All the preceding existing genera belong to the subfamily C but the Musk-Deer (*Moschus*), of the Himalaya and regions northward, is the type of a second subfamily—the *Moschinæ*.

, in which there are no antlers, and the upper canines of the attain an excessive development, not improbably occurs fossil e Pliocene of the Siwalik Hills.

AMILY GIRAFFIDÆ.—In this family, which is taken to include *Sivatheriidæ* of some authors, the cranial appendages, when ent, appear to be intermediate in character between those of *Bovidæ* and *Cervidæ*. The teeth are more or less brachydont, invested with a rugose enamel; their number being $I. \frac{0}{3}$, $C. \frac{0}{1}$, $\frac{3}{3}$, $M. \frac{3}{3}$. The type genus *Giraffa* (*Camelopardalis*), which at present day is represented only by *G. camelopardalis* of Africa, closely allied to the *Cervidæ*, in which family it is included by fessor Rütimeyer; the frontal appendages consist of a pair of



. 1218.—Skull and antlers of *Cervalces americanus*; from the Pleistocene of North America. Reduced. Letters as in figs. 1216 and 1217. (After Scott.)

ort, erect, bony processes, at first connected by suture, but subseently anchylosed to the skull, which are covered with hairy skin, d are present in both sexes. Anteriorly to these there is a median ocess on the frontals and nasals, which is sometimes termed a rd horn. There are no traces of lateral digits; the humerus has double bicipital groove; there is a lachrymal vacuity in the nium; and the neck and limbs are enormously elongated. ssil species occur in the Lower Pliocene of Greece, Persia, dia, and China. *Vishnutherium*, of the Siwaliks of Burma and dia, appears to be an allied genus, with shorter limbs, but the cranium is unfortunately unknown. The next place in the series is occupied by *Helladotherium*, of the Lower Pliocene of Greece, India, and perhaps Persia, in which the cranium is devoid of ap-pendages, and the molar teeth become more like those of the Elk. The limbs are comparatively short and stout; the cranium has no lachrymal vacuity; and the one known species was of considerably greater bulk than the Giraffe. With *Hydaspitherium*, of the Pliocene of North-western India, we enter the group in which the cranium was provided with large branching antler-like appendages, althoug the exact nature of their covering is unknown. These appendage in this genus rise from a common base situated immediately i advance of the occiput, but their form is not known; there we lachrymal vacuities in the cranium. An apparently allied for from the Pliocene of Persia, has been named *Urmiatherium*. *Bramatherium*, of the Pliocene of Western India, there were t

Fig. 1219.—Skull of *Sivatherium giganteum*; reduced. Pliocene, India. The positio the hinder antlers should probably be reversed.

pairs of these antler-like appendages, the anterior pair arising f a common base, and being of large size. Lastly, we have S *therium* (fig. 1219), of the Pliocene Siwaliks of North-eastern In in which the neck and limbs were not developed beyond the no proportions. There are two pairs of cranial appendages, the b of each being separate. The anterior pair are conical, like tho

Giraffe; while the posterior ones are palmate, and resemble the lers of the Elk. The latter pair are marked by the impressions large blood-vessels, as in the *Cervidæ*, but do not show the burr aracteristic of that family, from which it is inferred that they were t shed. There is no lachrymal vacuity in the cranium; the nasals short and arched; and the bones of the skeleton approximate structure to those of the *Cervidæ*. Some authorities regard this nus as most closely allied to brachydont Antelopes like *Strepsi-ros*, but it appears to be so intimately connected with the preced- forms that it seems imperative to place it in the same family, hough it may indicate an approximation to the *Bovidæ*.

The remarkable genus *Samotherium*, of the Lower Pliocene of Isle of Samos, is referred by Dr Forsyth-Major to the present ily, although its skull makes a remarkable approximation to that the antelopoid genus *Palæotragus*. The females were hornless, the males had a pair of small horns immediately above the t. The molars are described as being very like those of the iffe.

AMILY ANTILOCAPRIDÆ.—This family is now represented only he American Prong-buck (*Antilocapra*), in which the horns are le same nature as in the *Bovidæ*, but differ in being bifurcated, in the shedding of their sheath. Remains of *Antilocapra* occur le Pleistocene of North America; and it is thought that *Cosoryx*, le Pliocene of the same country, may have been the direct an- or of the existing genus.

AMILY BOVIDÆ.—In this, the last, family are comprised the specialised members of the whole suborder, such as the lopes, Goats, Sheep, and Oxen. The general characters of greater part of the skeleton are the same as those mentioned er the head of the *Cervidæ*; but a remarkable difference is d in respect of the frontal appendages. These appendages 1222) are paired, and consist of persistent bony processes, into h the air-cells from the frontal diplöe often extend; they are rally subconical or triangular, and often twisted, but never ched. These "horn-cores," as they are termed, are covered the true horns, which are composed of an epidermal fibrous ture, and are never shed. The males of all existing genera in wild state are furnished with these horns, and they are also ent, although of smaller size, in the females of the great rity. In certain domesticated races of so-called *polled* Sheep 1220), Goats, and Cattle, the horns are, however, wanting in sexes; and this peculiarity is with great probability regarded n instance of reversion, since these appendages are also wanting ome allied Tertiary forms of two of these groups. In the ium there is generally no lachrymal vacuity, and the lachrymal consequently articulates largely with the nasal (fig. 1220); but in certain Antelopes this vacuity is present, when the relations of these bones are the same as in the *Cervidæ*. Another very characteristic feature of the *Bovidæ*, as a whole, is the hypsodont character of their cheek-dentition. In many of the Antelopes (fig. 1221) this feature is only moderately developed, but in the Sheep, Goats, and Oxen it is carried to an excessive degree; and in the latter group the valleys of the teeth are filled up by a coating of cement. This feature, like that of the relations of the lachrymal, is, however, not absolutely distinctive of the *Bovidæ*, since we find many Antelopes

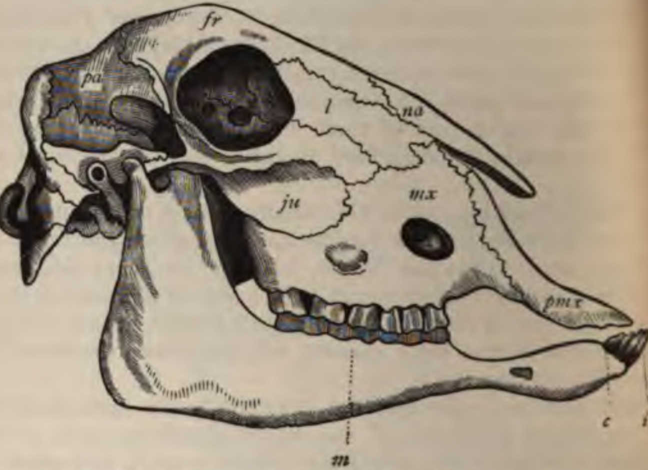


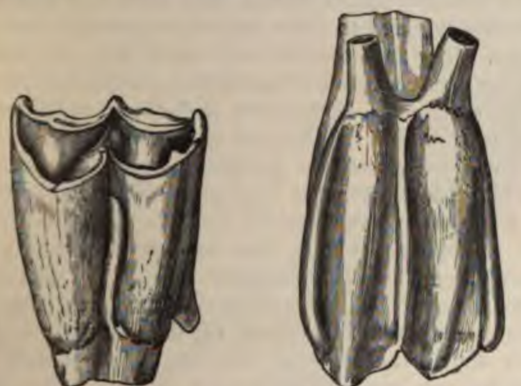
Fig. 1220.—Skull of a hornless Sheep (*Ovis*). Reduced. *i*, Incisors; *c*, Canines; *m*, Cheek-teeth; *pmx*, Premaxilla; *mx*, Maxilla; *na*, Nasal; *l*, Lachrymal; *ju*, Jugal; *fr*, Frontal; *pa*, Parietal. (After Owen.)

(and especially those having a lachrymal vacuity) with a decidedly brachydont dentition. The upper true molars frequently have a large accessory inner column (fig. 1221). Functional canines are wanting in all existing forms. The lateral digits may or may not be present, but in no living form is there a distal remnant of the lateral metapodials.

This family does not apparently date further back than the Middle Miocene, where it is represented by members of its least specialised group, the Antelopes; the Sheep and Oxen not appearing till the Pliocene. It has been suggested that the family originated from the same ancestral forms as the *Cervidæ*.

Commencing with the Antelopes, and confining our attention to those forms in which the genus has been more or less accurately determined, we find in the *Alcelaphine* section, which is now con-

Africa and Syria, the existing genus *Alcelaphus* represented ter Tertiaries of Algeria, and also in the Pliocene Siwaliks ; the species from the latter deposits being apparently th to the Hartebeast (*A. caama*) and the Bontebock (*A.*). These antelopes have recurved or lyre-shaped horns ; ull has no supraorbital pits, and may have a very long hile the molar teeth are very narrow. In the *Cephalopine* comprising Indian and African species of comparatively ze, the existing Four-horned Antelope (*Tetraceros quadri-* is found in a fossil state in the cave-deposits of Madras ;



1221.—Inner and outer views of the second left upper true molar of the Nilghai (*Boselaphus tragocamelus*). Recent ; India.

extinct species occurs in the Siwaliks. The African genus *bus* may perhaps also occur in the latter deposits. The *rine* section is now confined to Africa, and includes some e antelopes in which the females are hornless. *Cobus*, in ie skull has well-marked supraorbital pits, appears to be ted in the Indian Siwaliks by species as large as some of can forms. In the Pliocene Pikermi beds of Greece an with round lyrate horns, described as *Helicophora*,[1] appears lied in some respects with *Cobus*, although it has lachrymal , but no distinct supraorbital pits. In the typical *Antelopine* which is allied in many respects to the preceding, there are well-developed supraorbital pits, and the molar teeth are nt, and resemble those of the sheep. The type genus , which has round and spirally twisted horns, is known in stocene of India by remains of the one existing species *A.* *a* (Black-buck) ; the existing Siberian *Saiga tartarica* is

[1] Originally described under the preoccupied name of *Helicoceros*.

found fossil in the cave-deposits of Europe; while the Afr genus *Gazella*, in which the lyrate horns are laterally cor occurs in the Pliocene of Europe, Africa, and India, as the Norfolk Forest-bed. The *Hippotragine* section may be include the existing African genera *Oryx*, *Addax*, and *Hip* and is characterised by the long and straight, or backward horns, the absence of supraorbital pits in the skull, and and hypsodont upper molars, which resemble those of In a fossil state this section is represented by *Hippotra* Indian Siwaliks; and also by the extinct *Palæoryx*, of Pliocene of Greece, Italy, Samos, and France, which a have been closely allied to *Oryx*, although showing some *Hippotragus*. The last section into which the true exis lopes may be divided is the *Tragelaphine*, comprising *Bos* India, and *Tragelaphus*, *Strepsiceros*, and *Oreas* in Africa Indian genus, of which the Nilghai is the only existing r tive, the horns are short and upright, and are not pres females, while the dentition is hypsodont (fig. 1221); fo occur in India from the Siwaliks upwards. In the Afri the horns are spirally twisted, with two more or less w longitudinal ridges, the skull has deep supraorbital pits a mal vacuities, but no pit in the lachrymal itself, and the broad and brachydont like those of the *Cervidæ*. S (Kudu), in which the anterior ridge on the horns is stronger of the two, apparently occurs in the Indian Siwal may also contain a representative of the allied *Oreas* (Ela extinct *Palæoreas* (fig. 1222), of the Lower Pliocene of E Algeria, appears to have been allied to both the precedin while the so-called *Antilope torticornis*, of the Pliocene has the posterior ridge of the horns the most developed existing *Tragelaphus*, to which genus it has, indeed, bee The remarkable *Protragelaphus*, of the Lower Pliocene differs from all the preceding genera in that the horns h posterior longitudinal ridge, in the absence of supraorbita in the development of lachrymal depressions like those o *vidæ*. With the *Rupicaprine* section of this family we come showing characters connecting the true antelopes with but the only definitely known fossil remains belong to th alpine Chamois (*Rupicapra*), which occurs fossil in the cav of the Continent. Under the name of the *Palæotragi* may be included three extinct Tertiary genera having th compressed horn-cores of the goats, but the upper mola less like those of the brachydont antelopes. The earlies genera, and indeed of all the antelopes, is *Protragocer* Middle Miocene of France, one of the species having since described as *Antilope clavata* (*sansaniensis*). These were small forms, with short horns, and the crowns of the molars very short and moderately wide. In *Palæotragus* and *Tragoceros*, of the Lower Pliocene of Greece and Samos, the horns were larger, and the molars wider. The former genus is considered to be allied to *Samotherium*, noticed among the *Giraffidæ*. The true Goats and Sheep, collectively forming the section *Caprinæ*, are characterised by their more or less laterally compressed and often angulated horn-cores, which may be either curved backwards, as in the Ibex, spirally twisted, as in the Markhoor, or with a peculiar outward curvature and twist, as in the Sheep; the horns themselves being frequently

Fig. 1222.—Left lateral view of the cranium of *Palæoreas Lindermayeri*; from the Lower Pliocene Pikermi beds of Greece. Reduced. The lachrymal vacuity is omitted. (After Gaudry.)

marked on the anterior surface by transverse ridges. In all the genera the dentition is markedly hypsodont, and in existing forms the accessory inner column of the upper true molars is wanting. None of them show a lachrymal vacuity; but in the Sheep there is generally a deep depression (larmier) in this bone, which is absent in the Goats. *Capra* may perhaps occur in the Upper Pliocene of France; it is represented in the Pliocene of the Indian Siwaliks by one species (*C. sivalensis*), which is probably the ancestor of the Himalayan Thar (*C. jemlaica*); by another species equally closely allied to the Markhoor (*C. Falconeri*), of the same region; and not

improbably by a third allied to the Himalayan Ibex (*C. si*
Remains of the Pyrenean Ibex (*C. pyrenaica*) are found
Pleistocene cave-deposits of Gibraltar; and those of the co
Goat (*C. hircus*) in the turbaries and fens of England. Tl
remarkable hornless genus *Bucapra*, from the Siwaliks of In
a skull presenting a great resemblance to that of the Go
cheek-teeth like those of the Oxen. The true Sheep (*Ovis*)
to be a group of very late origin, and are scarcely known in
condition; a large species has, however, been described fr
Norfolk Forest-bed as *O.* (*Caprovis*) *Savigni*, which was ap
allied to the existing Argali. The Musk-Ox (*Ovibos*) of the
regions, which forms a connecting link between the *Capr*
Bovinæ, occurs fossil in the Pleistocene of Europe and
while two closely allied forms, from the Pleistocene of K
and Arkansas, have been respectively named *O.* (*Boötherium*
frons and *O. cavifrons*.

The members of the *Bovine* section, comprising about
recent species distributed over the greater part of Europ
Africa, and North America, agree with the *Caprine* section in
no lachrymal vacuities, but differ from the recent members
section in having the crowns of the cheek-teeth extremely t
large accessory columns in the upper true molars, and thei
filled up by a large quantity of cement. The horn-cores
either rounded, flattened, or angulated, and are frequently
more or less outwardly, but are never curved spirally inwar
the "cork-screw" shape characteristic of many Goats; w
horns themselves are not marked on their anterior surface b
nent transverse ridges. The most aberrant genus is *Lepto*
the Pliocene and Pleistocene of India and the Upper Plio
Italy, in which the frontal portion is broad, with widely s
horn-cores placed far below the level of the occiput. Th
cores are sometimes absent; and this genus is regarded as
Boselaphus. *Bubalus*, typically represented by the Buffaloes
and Africa, but which may also be taken to include the di
Anoa (*B. depressicornis*) of Celebes, is characterised by its a
horn-cores, which may be directed either outwards or upwa
by the great convexity of the forehead in the more typica
Among the more aberrant species may be reckoned three f
Siwalik Hills of India (*e.g.*, *B. occipitalis*), which are close
to the Anoa, and (together with that species) by some wri
termed *Probubalus*; the horn-cores are frequently complete
gular in section, and the forehead is not decidedly conv
platyceros from the same deposits is intermediate between
mentioned group and the existing Buffaloes. *B. antiquus* f
Pleistocene of Algeria is regarded by Professor Rütimeyer a

he existing African Buffaloes, although Dr P. Thomas s more nearly related to the living Indian species. The *buffelus*) is found in a fossil state in the Pleistocene of the 'alley, India; while an apparently closely allied form also the Pliocene of the Siwalik Hills. In *Bison*, now repre- the Aurochs of Lithuania (*B. bonasus*) and the nearly ed North American *Bison americanus*, the skull is charac- its great relative width and shortness, the tubular orbits, ately convex forehead, and the curved, round, horn-cores, placed considerably below the level of the occiput. The uropean species is represented by a variety (*priscus*) in cene of Europe and Arctic America; while the gigantic *s* of the Pleistocene of Texas may probably be looked e progenitor of the recent species of that country. A om the Pliocene of the Siwalik Hills has been referred to with the name of *B. sivalensis*, and appears to be allied to rms. The genus *Bos*, which is confined to the Old World, st specialised representative of this section, and may be to the *Bibovine* and *Taurine* groups. In the former are in- wild Oxen of India and Burma, which are characterised by

1223.—Cranium of the Urus, *Bos taurus*, var. *primigenius*, Pleistocene. Much reduced.

r less flattened horn-cores, and by certain peculiarities in f the occipital region. The earliest representative of this *'os etruscus* from the Upper Pliocene of the Continent, in horn-cores are placed very low down on the frontals; this ng considered to be nearly related to *B. banting* of Burma. perfectly known member of this group is *B. palæogaurus* stocene of India, which may turn out to be identical with

B. gaurus now living in the same regions. In the *Tauri* the frontals (fig. 1223) are extremely elongated, and the ho which in the type species are rounded, are placed immedia the occiput. To this group may be referred *B. planifron* *acutifrons* of the Pliocene of the Siwalik Hills; the latter markable for its sharply angulated frontals and its enorm cores, which have a pyriform section. Another member is *dicus* of the Pleistocene of Central India, which presents proximation to the *Bibovine* group; but the best known fo the Urus of the European Pleistocene (fig. 1223), which a be only a larger form of the existing Ox (*Bos taurus*), and the descendants of wild races are still preserved in Chillin some other British parks. A still smaller race, whose rem been found in the turbaries and fens of England, and h described under the names of *B. longifrons* and *B.* seems to be only a stunted variety of the same species, fro is probable that the small cattle of Wales and Scotland h derived.

SUBORDER 2.—PERISSODACTYLA.—The characters pos this suborder in common with the Artiodactyla are notic that head. The distinctive features of the Perissodactyla found in the truncated distal surface of the astragalus (fi the circumstance that the t in both the fore and hind fe metrical in itself, and la either of the others (fig. 1 presence (except in *Chali* of a third trochanter to t (fig. 1226); and the non-a of the fibula with the c Other characters very gen servable in this suborder are whole of the series of cheek in contact with one another upper premolars are nearly as complex as the true mo the last lower true molar frequently has no third lobe, when such third lobe is present, it is absent in the last lo molar; while the first tooth of the cheek series is some ceded by a milk-tooth. In all existing forms the numb dorso-lumbar vertebræ is never less than twenty-two, and twenty-three; while the nasals are expanded posterior stomach is simple, and the placenta diffused. In existi the cervical vertebræ are markedly opisthocœlous. The u molars are constructed on some modification of what is

Fig. 1224.—Anterior view of the left astragalus of the Horse (*Equus caballus*). One-half natural size.

nt plan (fig. 1228); that is, there is an outer longitu-
rom which two transverse ridges proceed at right angles
inner border of the crown. In the brachydont forms
re is perfectly simple, but in those genera with very
teeth it is so complicated by foldings and involutions
t always easy to trace the original plan. The crowns
true molars consist in their simplest structure of two
idges (as in the Tapir), but these ridges may be curved
its (as in the Rhinoceros), or complicated by foldings

ight manus of (A) *Tapirus*, and (B) *os*. Reduced. (After Flower.)

Fig. 1226.—Dorsal or anterior view of the left femur of *Rhinoceros*. The median projection on the right side of the figure is the third trochanter. Reduced.

itions (as in the Horse). The transition from the sim-
ydont to the most specialised hypsodont dentition is
d by a reduction of the number of the digits from four
one; that one being the third, or middle, of the typical
.

ssodactyla have suffered considerably more in proportion
nbers than the Artiodactyla by the extinction of generic
types; the existing genera being at the present day
three, which are the types of as many different families.
s have suggested that this extinction of types is owing
odont plan of molar structure being less readily suscep-

tible of modification than the Bunodont type upon which the Artiodactylate molar is constructed, but this is really a pure assumption.

FAMILY TAPIRIDÆ.—This family is represented by the single existing genus *Tapirus*, now found in the widely separated areas of the Malay Peninsula and South America, and thus affording an excellent example of what is termed discontinuous distribution. The dental formula is $I.\ \frac{3}{3},\ C.\ \frac{1}{1},\ Pm.\ \frac{4}{3},\ M.\ \frac{3}{3}$; the cheek-teeth are brachydont, and of the simple Lophodont type; the hinder premolars being as complex as the true molars, and the last lower molar having no third lobe. The first upper premolar has a deciduous predecessor; and in the existing forms there are four digits in the anterior (fig. 1225, A), and three in the hind foot. The cranium (fig. 1227) has its cerebral portion much vaulted, and the

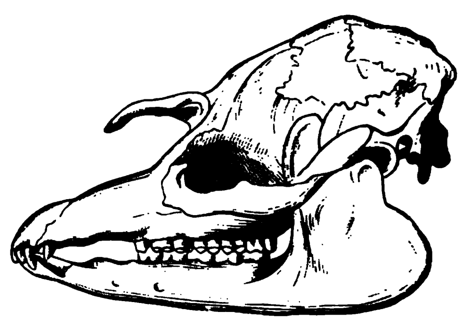


Fig. 1227.—Side view of the skull of *Tapirus americanus*. Reduced. (After Giebel.)

nasals short and arched; in one American species (which on this account is regarded by some authors as generically distinct under the name of *Elasmognathus*) the narial septum is largely ossified; and there is a short proboscis. In Europe this genus is found in the Middle Miocene of France (*T. Poirrieri*), and continues to the Upper Pliocene (*T. arvernensis*); it also occurs in the Pliocene of China (*T. sinensis*), and in the Pleistocene cave-deposits of Brazil, one of the forms from the latter being indistinguishable from the living *T. americanus*. The North American Miocene forms named *Tapiravus* are probably not generically distinct. An imperfectly known form from the Middle Eocene of France, described as *Palæotapirus*, is referred by Dr Filhol to this family.

FAMILY LOPHIODONTIDÆ.—This Eocene family presents characters allying it very closely with the *Tapiridæ*, *Palæotheriidæ*, and *Rhinocerotidæ*, and probably contains ancestral forms of all those families. The upper true molars (fig. 1228) are brachydont, and always more complex than the premolars; the last lower true molar

:nerally has a third lobe; and there are usually four digits in the ianus and three in the pes. The type genus *Lophiodon* (fig. 228, A) comprises some species which attain a bulk rivalling that of ie Rhinoceroses, and has the dental formula $I. \frac{3}{3}, C. \frac{1}{1}, Pm. \frac{3}{3}, M. \frac{3}{3}$. : is found in the Middle and Upper Eocene of Europe, and is :nerally regarded as having died out without descendants. In ie dentition here figured the inner crescent of the fourth upper remolar is incomplete, and the ridges of the lower molars are mple; the last lower true molar always has a third lobe. Allied *Lophiodon* is *Helaletes* (*Desmatotherium*), of the Upper Eocene f North America, characterised by the more rounded upper true iolars and the absence of a diastema in the lower jaw; it is re-

'ig. 1228.—A, The last five right upper cheek-teeth of *Lophiodon isselensis*, from the Middle cene of France; B, The right upper cheek-teeth of *Hyrachyus agrarius*, from the Eocene of rth America. Reduced.

rded by Professor Cope as an ancestral stock of the *Rhinocerotidæ*. ith forms from the North American Eocene described as *Isectolous* and *Prothyracodon*, in the first of which the last lower true olar has a third lobe, we come to the consideration of Lophionts showing more affinity with the Tapirs, but it does not appear ite certain that both these forms are really entitled to generic disiction from the next. The genus *Hyrachyus* (fig. 1228, B), which curs typically in the Uinta and Bridger Eocene of the United ates, is taken by Dr Filhol to include European Lophiodonts nging from the Middle Eocene of France to the Lower Miocene St Gérand-le-Puy. This genus has four premolars, of which the st is somewhat simpler than the first true molar; while there is third lobe to the last lower true molar. In the type species the upper true molars (fig. 1228, B) resemble those of the *Rh* *idæ;* but there appears to be a gradual transition in this towards *H. priscus*, of the Quercy Phosphorites, in whic teeth have rounded angles, and approximate to those of the from which, however, these forms are distinguished by the fourth premolar. This transition has induced Dr Filhol t the genus *Protapirus*, which was proposed for *H. prisc* latter species is evidently allied to the American *Isectolop* Dr Filhol suggests a transition from this type towards th The typical American species of *Hyrachyus* is regarde ancestor of the genus *Hyracodon*, which is classed in the *i* *tidæ*. An American species which may be provisionally in *Hyrachyus* is said to have an attachment for a derma each nasal, on which account it is separated by Professor *Colonoceros*. The American Eocene genus *Dilophodon* a be allied to this group.

The imperfectly known genus *Ribodon*, from the infra beds of Patagonia, is apparently nearly allied to *Hyrachy* genus *Triplopus*, of the Upper Eocene of the United Stat tinguished by having only three digits in the manus, account Professor Cope makes it the type of the family *idæ*. In *Hyracotherium*, with which the forms describ the names of *Pliolophus* and *Orohippus*, and not impro *hippus*, are identical, the upper true molars resemble those *odon*, but their anterior ridge is incomplete, and the transve of the lower cheek-teeth have a tendency to assume a cresc In this genus there is a diastema behind the first premol an allied form from the Lower Eocene of North America, been named *Systemodon*, all the teeth are in contact. The species of *Hyracotherium* indicate animals not larger th the dentition is of the full typical number, and the structu fore-foot is shown in fig. 1236, A. This genus occurs in t Eocene[1] both of Europe and North America, and, as wil fully noticed below, it is regarded as the ancestral sto *Equidæ*. *Heptodon*, from the Eocene of New Mexico, v originally identified with *Pachynolophus*, appears to co latter with *Hyracotherium*, although it is placed by Profe next to *Hyrachyus*. In *Pachynolophus* the dental formula full typical number; but the upper true molars have tal than in *Hyracotherium*, and are intermediate in structure those of the latter and of *Anchilophus;* the lower mol subcrescentoid. The largest species is *P. isselanus*, but

[1] It has recently been recorded from the Middle Eocene and the I of France; but at least one of the species from the latter deposits form more nearly allied to *Anchilophus*.

ral other forms from the Middle and Upper Eocene of the tinent; *Propalæotherium* (in which *Lophiotherium* may be in-led) does not appear generically separable.

AMILY PALÆOTHERIIDÆ.—With the *Palæotheriidæ* we enter n another extinct family of this suborder, the type genus of which long been known from the classic labours of Cuvier. In this ily the upper premolars may be either simpler or quite as com- as the true molars; the lower molars have crescentoid crowns, in the last tooth of this series the third lobe may be either well loped or almost wanting; all the cheek-teeth are brachydont, when cement is present it does not fill their valleys. There lways three digits in each foot. The type genus *Palæotherium*, hich may be included *Paloplotherium* (or *Plagiolophus*), ranges the Middle Eocene of the Paris basin to the Lower Miocene onzon, but is especially characteristic of the Parisian stage. dental formula is $I. \frac{3}{3}, C. \frac{1}{1}, Pm. \frac{(3-4)}{(3-4)}, M. \frac{3}{3}$; and the last molar has a third lobe. In the more typical species (fig. 1229) our premolars are present in both jaws, the fourth upper pre-

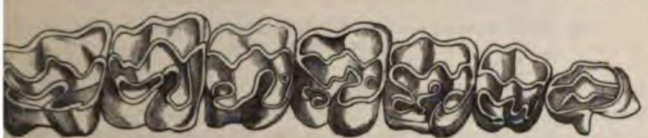


Fig. 1229.—The right upper cheek-dentition of *Palæotherium crassum*; from the Upper Eocene of Paris. Reduced.

r is as complex as the first true molar, and the third lower pre- r as the fourth lower premolar; while the diastema is compara- short, and the canines are not large. The upper true molars the species exhibit an expansion of the inner extremities of the verse ridges, foreshadowing the structure of the teeth of some e *Equidæ*. The cranium is Tapiroid in character, especially in prominence of the nasal bones; from which it is deduced with probability that the nose possessed a short movable proboscis. general form may also be supposed to have been like that of Tapirs, and the restoration of *P. magnum* given by Cuvier (fig.) exhibits to us an animal closely similar to the existing Tapir. is particular instance, however, we know that the restoration is rect, since the discovery of a complete skeleton of this species shown that it was a more slender and longer-necked animal, nbling in its general figure a Llama.

that group, which is considered by some writers as generically dis- under the name of *Paloplotherium*, the last upper premolar has its hinder lobe more or less completely aborted, the third lower pr less complex than the fourth, the first lower premolar is absent corresponding upper tooth may also be wanting; when the la is present it is sometimes preceded by a milk-molar. In this *Javali*, from the Quercy Phosphorites, is remarkable for the p a considerable quantity of cement in the cheek-teeth, and for th mation of the upper canine to the premolars and its apparent from the incisors. *P. minus* from the Paris basin is the small

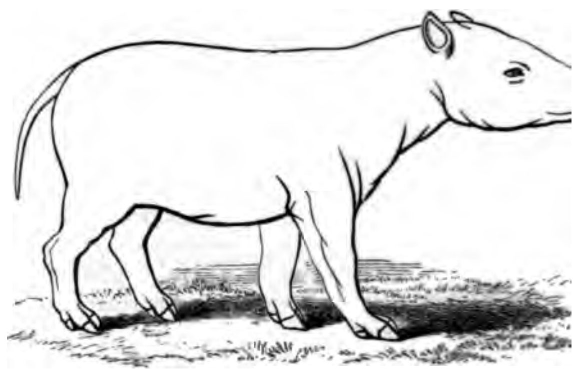


Fig. 1230.—Reduced restoration of ***Palæotherium magnum***, after Cuv Upper Eocene, France.

of the genus; while *P. codiciense*, from the Middle Eocene of F its fourth upper premolar as simple as in *Lophiodon* and *Hyra* thus shows how extremely intimate is the relation between all forms of the suborder, and how very difficult it is to give an tinctive characters of the families into which it is convenient them.

In *Anchilophus*, of the Upper Eocene of the Continent, formula is $I. \frac{3}{3}$, $C. \frac{1}{1}$, $Pm. \frac{?4}{3}$, $M. \frac{3}{3}$; and the cheek-teeth

Fig. 1231. — A left upper true molar of *Anchitherium aurelianense*; from the Middle Miocene of France.

intermediate in structure between those *nolophus* and *Anchitherium*. The last molar is as complex as the first true mo are well-marked ridges on the outer c the upper true molars; the last lower t has a large third lobe; and the diasten gated. The genus ***Epihippus*** from tl Eocene of North America, which is by some writers as being on the direc of the Horse, has been placed her Schlosser. The genus forming a step i of *Anchilophus* is *Anchitherium*, typic the Middle Miocene of Europe, but with which the con North American forms described under the names of *A* and *Miohippus* may be united. The dental formula is the typical one; the upper premolars are as complex as the true molars (fig. 1231), the external surface being without a median vertical ridge; the first lower premolar is comparatively small; and the third lobe of the last lower true molar is reduced to a small talon; while the incisors have no infolding of the enamel at their summits. Some species show a "larmial" depression in the lachrymal. The typical *A. aurelianense* (fig. 1231), of the Middle Miocene of the Continent, is the largest species, and shows no trace of the fifth metacarpal; while the meso- and entocuneiform of the tarsus are united. In the smaller *A. Bairdi* of the Miocene of North America the lateral digits are relatively larger, the fifth metacarpal is represented by a splint, and the meso- and entocuneiform are separate. Allied to this genus are *Anchippus*, *Parahippus*, and *Hyohippus* of the North American Miocene.

Fig. 1232.—Lateral view of the right manus of the Horse (*Equus caballus*). Reduced. *ca*, Carpus; *m*, 3d Metacarpal (cannon-bone); *s*, Lateral do.; 1, 2, 3, Phalangeals of third digit.

Family Proterotheriidæ.—In this place it may be convenient to notice the genus *Proterotherium* from the Tertiary of Patagonia, which was at first regarded by Dr Ameghino as belonging to the Artiodactyla, but was subsequently made the type of a distinct family of this suborder. One species was referred by Bravard to *Anoplotherium*, while a second was subsequently described by Dr Burmeister first as *Anchitherium*, and then as *Anisolophus*. The upper premolars are nearly as complex as the true molars. The names *Thoatherium*, *Diadophorus*, and *Licaphrium* have been applied to allied forms from the same deposits. The lower molars have four distinct roots. It may be questioned whether these forms are really entitled to form a distinct family.

Family Equidæ.—The division between this family and the *Palæotheriidæ* is a more or less arbitrary one. In the present one the upper premolars are as complex as the true molars, and all the cheek-teeth are usually of an extremely hypsodont type, with their valleys filled with cement; the crowns of the lower molars are crescentoid, with complex folds of enamel, and there is scarcely any distinct third lobe to the last lower molar. The digits may be either one (fig. 1232) or three in number; the ulna and fibula a incomplete; and the meso- and entocuneiform of the tarsus a united. The plane of wear of the cheek-teeth becomes ne smooth, instead of being raised into ridges as in the precedi families; and the summits of the incisors have an infolding of t enamel extending some distance into the crown. One of the mo generalised forms is *Protohippus* or *Merychippus* of the Lo Pliocene of North America, in which the permanent molars semble those of the generalised species of *Equus*, but have sho crowns, while the milk-molars approximate more nearly to the t molars of *Anchitherium*. The next genus is *Hipparion* (*Hi therium*). The dentition is $I. \frac{3}{3}$, $C. \frac{1}{1}$, $Pm. \frac{4}{3}$, $M. \frac{3}{3}$; but the upper cheek-tooth, which has no predecessor and appears the milk series, is shed before the animal is adult. The u cheek-teeth (fig. 1233) at first sight seem to differ very wi

Fig. 1233.—Three right upper cheek-teeth of *Hipparion*; from the Pliocene of Indi Posterior, and *b*, Anterior outer crescent; *c*, Anterior, and *d*, Anterior inner crescent; *e*, rior, and *f*, Posterior pillar.

from those of the *Palæotherium* type (fig. 1229), but a c examination will show that the outer portions marked *a* and *b* respond to the outer wall of the more generalised tooth; whil portions *c* and *e*, and *d* and *f* respectively represent the first second transverse ridges of the same. These ridges have, how united together in a crescent-like form, and enclose between and the outer wall a pair of islands surrounded by a plicated w enamel and filled with cement. The terms which it is conve to apply to the Equine molar are indicated in the accompa figure; and the distinctive feature of the upper teeth of *Hipp* is that the anterior pillar (*e*) is disconnected from the anterior crescent (*c*) for at least three-quarters of its height, so that it mally appears on the worn crown as an isolated oval (fig. 1 There are normally three digits to each foot, but in the Pli Indian *H. antilopinum* they are apparently reduced to one;

form having been made the type of the genus *Hippodactylus*. The best known species is *H. gracile* of the Pliocene of Europe, Samos, Persia, and Algeria; but the genus is also well represented in the Pliocene of India (*H. antilopinum*, *H. Theobaldi*), China (*H. Richthofeni*), and North America. All the species retain the primitive feature of a depression in the lachrymal. With *Equus* (in which may be included the American *Hippidium*, otherwise *Pliohippus*) we come to the most specialised of all the Perissodactyla. The dentition is $I. \frac{3}{3}$, $C. \frac{1}{1}$, $Pm. \frac{(3-4)}{(3-4)}$, $M. \frac{3}{3}$; but the first upper cheek-tooth is usually absent in existing forms, and the corresponding lower one is only occasionally developed in some extinct species. The crowns of the cheek-teeth are higher than in *Hipparion*, and the anterior inner pillar of the upper ones, except in a very early stage of wear, is connected with the adjacent inner crescent (fig. 1234). There is but one functional digit to each foot, although the

Fig. 1234.—The last four right upper cheek-teeth of the Horse (*Equus caballus*). Reduced.

proximal portions of the lateral metapodials remain (figs. 1232, 1236, D), and in the so-called *Hippidium* the terminal phalangeals were represented by claws. A maxillo-lachrymal fossa is present in the extinct *E. andium* and *E. sivalensis*, but is wanting in all existing species. At the present day this genus is confined to the Old World, and is especially characteristic of Africa, but in the Pliocene and Pleistocene it was spread over both North and South America.

In those South American Pleistocene forms referred by some writers to *Hippidium*, the molars are shorter and more curved than in existing species, and the grinding surface of the anterior pillar of the upper ones is not wider than in *Hipparion*; *E. principalis* is a large species of this type. In *E. Stenonis* of the Upper Pliocene of Italy, Kos, and Algeria, and the Norfolk Forest-bed, the molars are taller, but they still have a narrow anterior pillar in the upper jaw, and thus show their nection with *Hipparion*. In *E. sivalensis*, of the Pliocene of India, *E. quaggoides* of that of Italy, this pillar becomes rather more wide and in the Pleistocene *E. namadicus* of India, as well as in *E. curv* of that of Brazil, and all the existing members of the genus (fig. the grinding surface of this pillar becomes greatly widened in antero-posterior direction. It is noteworthy that *E. sivalensis* is f in the same beds as those containing *Hipparion;* and that the ex *E. caballus* is apparently the common species of the European Pl cene, although it is not improbable that the Asiatic *E. onager* may occur in the same deposits. In Southern India, where no living sp are found, the remains of the existing African *E. asinus* and of a l

Fig. 1235.—Skull of the Horse (*Equus caballus*). Reduced.

undetermined form occur in the Pleistocene cave-deposits of Ma Finally, it should be mentioned that some of the South American Te forms have been separated under the name of *Haplohippus*.

GENEALOGY OF THE HORSE.—Allusion has been incidentally in the preceding paragraphs to the genealogy of the genus *Equu* since this is one of the best instances of evolution among the h Mammals yet worked out it is advisable that it should be noticed more fully. The top of the series is the *Equus caballus* group, in the dentition is of the most specialised type, and which descends in to the topmost Pliocene; then we have the *E. Stenonis* and *E. prim* group, in which the molars become more like those of *Hipparion* finally the so-called *Hippidium*. The structure of the foot is sho fig. 1236, D; the great size of the phalangeals and the metapodial functional digit being very noticeable. The earliest occurrence of the is in the Pliocene of India. From the *E. Stenonis* group to *Hipp* is but a step, the transitional species being *H. antilopinum* of the cene of the Siwalik Hills in which the lateral digits were appa wanting; in the other species (fig. 1236, C) the lateral digits small size, and the middle one is relatively more slender than in *I* *Protohippus* connects *Equus* by the structure of its milk-molar the Miocene *Anchitherium:* and in the latter the teeth have b brachydont, the third lower molar has a small third lobe, and the gits of the foot (fig. 1236, B) have become larger and the middle digit aller; traces of the fifth metacarpal being retained in the American ecies. The next step is probably made by some form allied to *Anchi-* *lus* or *Pachynolophus* of the Upper Eocene; and from such a type e transition is easy to the Lower Eocene *Hyracotherium* and *Systemo-* *n*, in which all the species are very small, the dentition is of the simple phodont type, with a large third lobe to the last lower true molar, and e fore-foot (fig. 1236, A) has four complete digits, which are of sub- al size; while there may be (*Eohippus*) a rudimental metacarpal of e pollex. Finally, the earliest stage of this series is formed by *Phenac-* *us* of the Lowest or Puerco Eocene of North America, in which there e five digits to each foot, and of which the structure will be more lly noticed under the head of the suborder Condylarthra. It should e observed, however, that Professor Cope would introduce an inter-

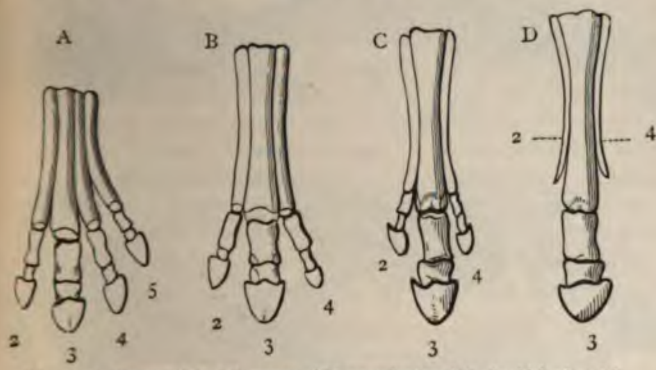


Fig. 1236.—Bones of the left manus of *Hyracotherium* (A), *Anchitherium* (B), *Hipparion* (C), and *Equus* (D).

ediate stage between *Systemodon* and *Phenacodus*; and that the same thority also introduces the genus *Palæotherium* between *Hyraco-* *rium* and *Anchitherium*, although most writers regard that genus as ite off the line.

In this connection may be noticed the remarkable circumstance that the line of evolution culminating in the modern Horse a parallel ries of generically identical or closely allied forms occurs in the Ter- ries of both Europe and North America, from which it has been sug- sted that in both Continents a parallel development of the same genera s simultaneously taken place—*i.e.*, that in both regions *Anchitherium* s given rise to *Hipparion*, and *Hipparion* or an allied type to *Equus*. ow, seeing it is evident that in the case of species of a single genus e evolution has taken place in separate lines,—that is to say, that the isting Indian species of *Canis* are probably derived directly from the iocene forms of the same region, and the Brazilian species of that nus have their predecessors of the cave-epoch of that country,—there pears no logical reason for refusing to admit an analogous parallel olution in the case of genera, and there is accordingly a considerable obability that the hypothesis in question may be a true one. Pro- ssor Cope considers that in one country *Protohippus*, and in the other *ipparion*, was the immediate ancestor of *Equus*.

FAMILY RHINOCEROTIDÆ.—With this family we enter u
consideration of another branch probably derived from th
tive Lophiodont stock, which attained great development
tiary times, and is still represented in Asia and Africa b
five well-defined species. It is not easy to distinguish th
from the *Lophiodontidæ*, as represented by *Hyrachyus* (

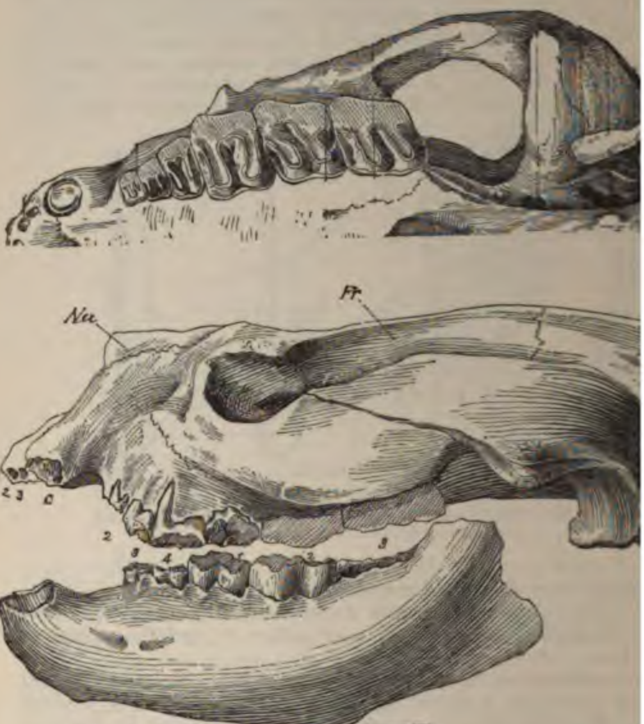


Fig. 1237.—Left half of the palatal surface of the cranium, and left lateral asp of *Metamynodon planifrons*; from the White River Miocene of North Ameri natural size. *Na*, Nasal; *Fr*, Frontal; *Pa*, Parietal; *So*, Supraoccipital; *zm* glenoid and posttympanic processes; 1, 2, 3, Alveoli of incisors; *c*, Alveolus of Premolars; 1, 2, 3, True molars. (After Scott and Osborn.)

Schlosser includes in the *Rhinocerotidæ*), but the upper t
(fig. 1239) generally have a very thick outer wall, whic
produced in advance of the first ridge; their transverse
but slightly bent, and are intimately connected with the
the upper premolars are usually nearly or quite as com
true molars; the lower cheek-teeth are more or less

toid; and in all the forms in which that tooth is known no third lobe to the last lower true molar. The height of ek-teeth varies considerably, their crowns being tallest in *herium*. One or more dermal horns may be attached to ito-nasal region; and when two of these appendages are they may be either placed one behind another in the middle in a pair on either side of this line. The digits of the pes rently always three, but there may be either three or four ianus. One of the most generalised forms is *Hyracodon*, Lower Miocene of Nebraska, in which the dental formula *C.* $\frac{1}{1}$, *Pm.* $\frac{4}{4}$, *M.* $\frac{3}{3}$. There were apparently only three digits; and limbs were slender and Horse-like; and there was no a nasal horn. This genus was in all probability a de- of the Lophiodont *Hyrachyus*, but does not appear to en the progenitor of the true Rhinoceroses. In some re- ill more generalised is the genus *Amynodon* (*Orthocynodon*), Middle and Upper Eocene of North America, in which tal formula was the same as in *Hyracodon*. The lower were nearly upright; there was a short diastema; the pre- were unlike the true molars; and it is believed that the iad four digits. Allied to this genus is *Metamynodon*, from cene of the United States, in which the skull (fig. 1237) ong sagittal crest, the premolars are reduced to $\frac{3}{2}$, the lower have become somewhat proclivous, and the upper premolars h more like the true molars. These two genera are regarded of the American ologists as indicat- istinct family—the *ontidæ* — and are oked upon as the s of the true Rhi- s. In the Old there is, however, us *Cadurcotherium* uercy Phosphorites, may possibly lay this position, al- it may indicate a ranch allied to the ntia. Unfortunate- detached teeth are at present known, so that the dental cannot be determined. The upper true molars (fig. 1238)

Fig. 1238. — A left upper true molar of *Cadurcotherium cayluxense*: from the Upper Eocene of France.

are Rhinocerotic in structure, but are extremely narrow verse direction, and the ridges of the lower cheek-teeth fectly crescentoid. Apparently nearly related to the p *Homalodontotherium*, from Tertiary strata of unknown a gonia; the dental formula is the typical one, and there is n but the skeleton is unknown. We now come to the cc of those animals which we may term true Rhinoceroses– which very diverse views as to the limits of generic te valent among zoologists and palæontologists. By some five existing species are referred to at least three dist and if this view be adopted, it will be necessary to m number of genera for the extinct forms; the English s ever, now generally include all the living species in one from this point of view there seems no good reasons fo separating any of the extinct species, which form a se mately connected that it would be very difficult to de genera into which they are divided by the American scho then, the term *Rhinoceros* in its widest sense, the varia number of teeth may be expressed by the formula $I. \frac{(0-}{(0-}$

$Pm. \frac{4}{4}$, $M. \frac{3}{3}$; the absence of upper canines is a distinc the upper true molars (fig. 1239) have their crowns rel their transverse ridges well developed, the hinder lobe

Fig. 1239.—The left upper true molars of *Rhinoceros megarhinus*; from th of England. One-half natural size.

tooth partially aborted, and frequently a more or less tress at their antero-external angle. The teeth repres 1239 are the most generalised type; and it is evident that

[1] In this and other instances the number of generic divisions wh disposed to adopt is solely a matter of convenience. From the w view the multiplication of generic terms, which as our knowledge become less and less susceptible of exact definition, tends to drown a sea of names, which form a great burden to the memory, and th stroy the very object of classification.

rown of each molar would carry two isolated fossettes by enamel (fig. 1244). The worn crown-surface is trans-ed; and there is a process projecting from the hinder he middle valley termed the crochet, which is absent in es. The hinder premolars are as complex as the true d the crowns of the cheek-teeth, though varying in never very tall, and their valleys are always open. In eek-teeth the ridges form complete crescents, with their lirected inwardly (fig. 1240). canines are always proclivous. n and skull are very massive, being most marked in the more species. This genus may be several groups, of which the is the most generalised. In there is usually no horn, and ones (fig. 1241) are conse-all; cutting-teeth are always ough there is some variation

Fig. 1240.—The third left lower true molar of *Rhinoceros megarhinus;* Pleistocene. Two-thirds natural size.

ber, which may be expressed by the formula $I. \frac{(0-2)}{1}$,

R. *incisivus* (which is the type of the so-called *Acera-*

ere are four digits in the manus; but in many of the rican forms (which on this account are separated by

-Cranium of *Rhinoceros incisivus:* from the Lower Pliocene of Germany. One-seventh natural size. (After Kaup.)

ope under the name *Aphelops*, fig. 1242) the number s reduced to three; and these forms were thus similar ale examples of the existing *R. sondaicus*, in which the nt. In Europe this group ranges from the Lower Miocene to the Lower Pliocene; it also occurs in the Upper Miocene and Pliocene of India, and in the Upper Miocene (or ? Pliocene) of North America. In the *Diceratherine* group (*Diceratherium* of

Fig. 1242.—Skull of *Rhinoceros megalodus*; from the Upper Miocene of Colorado. One-sixth natural size. (After Cope.)

Marsh) there was a transversely-placed pair of small nasal horn the formula of the cheek-teeth being $I. \frac{1}{1}$, $C. \frac{0}{1}$: it is represent in the Lower Miocene of Europe by *R. minutus*, and by anoth species in North America. At this stage of evolution the gen disappeared from the latter country.

The *Rhinocerotine* group is characterised by the presence of single well-developed nasal horn,[1] and of cutting-teeth in both jaw It is represented at the present day by the Asiatic *R. sondaicus* a *R. unicornis* (fig. 1243), the upper true molars of the former bei of the type of those of *R. megarhinus* (fig. 1239), while those of t latter are of the more specialised type of *R. antiquitatis* (fig. 124 The ancestor of *R. sondaicus* is probably to be found in *R. sivalen* of the Pliocene of India; while *R. palæindicus* appears to be t species from which *R. unicornis* has sprung. The *Ceratorh* group, represented by the existing Asiatic *R. sumatrensis*, and t European Lower Pliocene *R. Schleiermacheri*, differs from the p ceding by having two horns, placed one behind the other in t median line, but still retains cutting-teeth in both jaws; the up

[1] The horn of the Rhinoceroses, it should be observed, consists merely bundle of closely agglomerated bristles, and has no bony attachment to skull.

in both species being of the type of fig. 1239. This group probably be separated from the next, with which it is con- by *R. persiæ*, of the Pliocene of Maragha in Persia, which wer canines, although apparently allied to *R. platyrhinus*. most specialised, or *Atelodine*, group is represented at the

1243.—Worn left upper dentition of *Rhinoceros unicornis*; India. Much reduced. (After Cuvier.)

t day by the African *R. simus* and *R. bicornis*, in which there o large horns, but no cutting-teeth in either jaw. Of species pper molars of the simpler type of fig. 1239, we may mention *hygnathus*, of the Lower Pliocene of Greece and the isle of , which is closely allied to the African *R. bicornis*; *R. s* (fig. 1244), of the Upper Pliocene of Europe (in which

44.—Palatal view of the cranium of *Rhinoceros etruscus*, with the teeth much worn; Upper Pliocene, Italy. One-seventh natural size.

olars are of a brachydont structure); *R. deccanensis* and *R. iensis*, of the Pleistocene of Southern India; and *R. mega-* (fig. 1239) and *R. leptorhinus*, of the European Pleistocene. latter there is an ossification of the nasal septum. The members of this group have their upper molars (fig. 1245) of a more complex type; there being an absence of a buttress at antero-external angle, and the folds of the crown so arranged when more worn than in the figured specimen three island enamel would be formed on their crowns. These teeth are characterised by their plane of wear being perfectly horizontal, by their relatively tall crowns. An early member of this type *platyrhinus*, of the Pliocene of Northern India; from which sp

Fig. 1245.—The second right upper true molar of *Rhinoceros antiquitatis*; from Pleistocene of Kent.

it is highly probable that both the existing African *R. sim* the Pleistocene *R. antiquitatis*, of Northern Asia and Europ been derived.

The latter species, of which the skull is represented in fig. 1246 upper molar in fig. 1245, is sometimes known as the Woolly Rhin since it was covered with a thick coat of woolly hair. The sk devoid of the folds which characterise the large Indian species; front horn was of very large size. As in some of the Pleistocene the septum of the nares was completely ossified (fig. 1246). This is essentially a northern form, and has nearly the same distr as the Mammoth, although it does not appear to have crossed Strait into America. In time this Rhinoceros makes its first app in the Pleistocene Brick-earths of the Thames valley, and is very c in European cave-deposits, and in the *tundras* of Siberia. C carcasses, still covered with the dried flesh, skin, and hair, have no quently been found washed out from the frozen alluvial deposits *tundras* on the banks of the Yenesi and Lena; from which we le is animal mainly consisted of the leaves and twigs of juniper iiferous plants.

representative of this family is the gigantic *Elasmo-reoceros*) of the Pleistocene of Siberia, in which the ıla of the adult is $I. \frac{0}{0}, C. \frac{0}{0}, Pm. \frac{2}{2}, M. \frac{3}{3}$. The struc-kull and limbs is essentially Rhinocerotic; and in the ıarial septum was completely ossified, and the frontals bony protuberance for the support of a large horn ıg to the second one of *Rhinoceros antiquitatis.* The considerably from those of any species of *Rhinoceros*,

ht lateral aspect of the skull of a young individual of *Rhinoceros antiquitatis;* from the Pleistocene of Siberia. Reduced.

ıracterised by their very tall crowns, plicated enamel, plane of wear. Their structure is, however, merely an dification of the Rhinocerotic type, to which the nearest nong later forms is made by *R. antiquitatis.* There is, these teeth a marked resemblance to those of *Cadurco-*l *Homalodontotherium*, and it is not improbable that *um* presents the last representative of a stock descended ırmer genus which has remained altogether apart from hinoceroses.

LAMBDOTHERIIDÆ.—With the *Lambdotheriidæ* we enter ınsideration of the first of three extinct families in which eeth have remarkably short (brachydont) crowns, and certain extent from the more typical Lophodont form. true molars (fig. 1247) may be described as consisting ımns, of which the two hindmost are frequently con-ın oblique transverse ridge; while there may also be a ıplete anterior ridge. When these teeth are worn two

V-shaped surfaces of dentine appear on the crown. This tooth may be derived from the Lophodont by the more complete abortion of the middle portions of the transverse The upper premolars are simpler than the true molars, a but a single inner column; while the lower cheek-teeth are toid, the last true molar usually not having a complete thi

Fig. 1247.—The third right upper true molar of *Chalicotherium sinense*; from the Pliocene of China.

There was always a diastem dental series, and the skull void of bony protuberanc the present North America the femur has a third trocha the feet are of the normal dactylate type, the manus b vided with four, and the three digits. This family sented by *Palæosyops* an *therium*, from the Upper E which there are four prem the last lower true molar h lobe; the canines being resembling those of the *Lambdotherium* is anothe later age; while in the White-river Miocene of Canada *Haplacodon*, with only two pairs of lower incisors.

FAMILY CHALICOTHERIIDÆ. — The second family, o *theriidæ*, is found in both the Old and the New Worlds sents such a remarkable abnormality in the structure of as to render it for the future quite unsafe to predict the of an animal from a single bone, and to make invali

Fig. 1248.—Anterior and distal aspects of a second phalangeal of *Chalicotherium sivalense*; from the Siwaliks.

maxim *ex ungue le* the femur the chanter has been in the feet, while mal bones retain th Perissodactylate the phalangeals h modified to resem of Edentates, th phalangeal (fig. 1 ing a strongly deve tal trochlea for th tion of the huge claw forming the terminal joint. The geals have been described under the names of *Ma* and *Ancylotherium*, and were until quite recently, when found by Dr Filhol in association with the skull and the skeleton of *Chalicotherium*, thought to belong to huge ntates. The latter writer has indeed proposed to regard this as as a veritable Edentate, but the resemblance of its denti- to that of *Palæosyops*, coupled with the essentially Perisso- tylate characters of the rest of the skeleton — notably the thocœlous cervical vertebræ — prevents the acceptation of view, and compels us to regard this strange animal as a ly modified and aberrant Ungulate.[1] In the type genus *licotherium*, with which *Macrotherium* is identical, there were ations in the number of the cutting-teeth analogous to those ining in *Rhinoceros*, which may be expressed by the formula $\frac{-3)}{-3)}$, $C. \frac{(0-1)}{1}$, $Pm. \frac{3}{3}$, $M. \frac{3}{3}$. The type species, which should nown as *C. giganteum*, occurs typically in the Lower Pliocene ppelsheim in Hessen-Darmstadt, and also in the Middle Mio- of Sansan in Gers; the claws were first described by Cuvier r the name of *Pangolin gigantesque*, and were subsequently e the type of the genus *Macrotherium*. Another species, *C. cum*, occurs in the Upper Eocene Phosphorites of France, to h probably belong some large claws described as those of an ntate. The genus also occurs in the Pliocene of China and a; the species from the latter area having been referred by p to a distinct genus *Nestoritherium*, on account of the absence e anterior teeth. The phalangeal from the Pliocene of Sind sented in fig. 1248 doubtless belongs to a small individual is species, although first described as *Manis*, and subsequently *acrotherium*. It has likewise been lately recorded from the e-river Miocene of Canada and the Loup-Fork beds of sas. The last lower molar of *Chalicotherium* has no third

From the Lower Pliocene of Attica the genus *Leptodon*, ribed on the evidence of a lower jaw with a Chalicotheroid ition, but with a third lobe to the last molar, is probably iden- with *Ancylotherium*, founded upon the evidence of claws from ame beds, which are of the same general type as those of the lled *Macrotherium*. *Ancylotherium* also occurs in the Lower ene of the isle of Samos. *Leptodon* has been provisionally red by Dr Schlosser to the next family. *Moropus*, from the -Fork of Kansas, and *Morotherium*, from the Miocene of the ed States, which were described by Professor Marsh as Eden- , are probably closely allied to, if not identical with, either *licotherium* or *Ancylotherium*. Finally, the imperfectly known *chydiastematotherium*, from the Eocene of Hungary, is probably

[1] Professor Cope has recently proposed to make *Chalicotherium* the type of a ct order under the name of Ancylopoda.

other writers, is so closely connected by *Diplacodon* w
theriidæ, that Dr Schlosser has proposed to unite th
present family at least the fourth upper premolar
columns, and is thus as complex as the true molars
forms of which the limbs are known there are four an
posterior digits. The third trochanter of the femur
Paired bony protuberances may be present in the fro
of the skull. In *Diplacodon*, of the Eocene of Nort
the fourth upper premolar is as complex as the
canines are as large as in *Palæosyops;* the incisor
and the skull has no bony protuberances.

The type genus *Titanotherium*, which Messrs Sc
consider should include *Menodus* (preoccupied), *M*
totherium, *Diconodon*, and probably *Symborodon*, is

Fig. 1249.—Left lateral aspect of the cranium of *Titanotherium colo*
Miocene of North America. Greatly reduced. (After M

Miocene of North America, and comprises animals
and it is probable that the forms recently describ
Marsh under the names of *Allops*, *Brontops* (fig. 12
are not really separable. An entire skeleton is sho

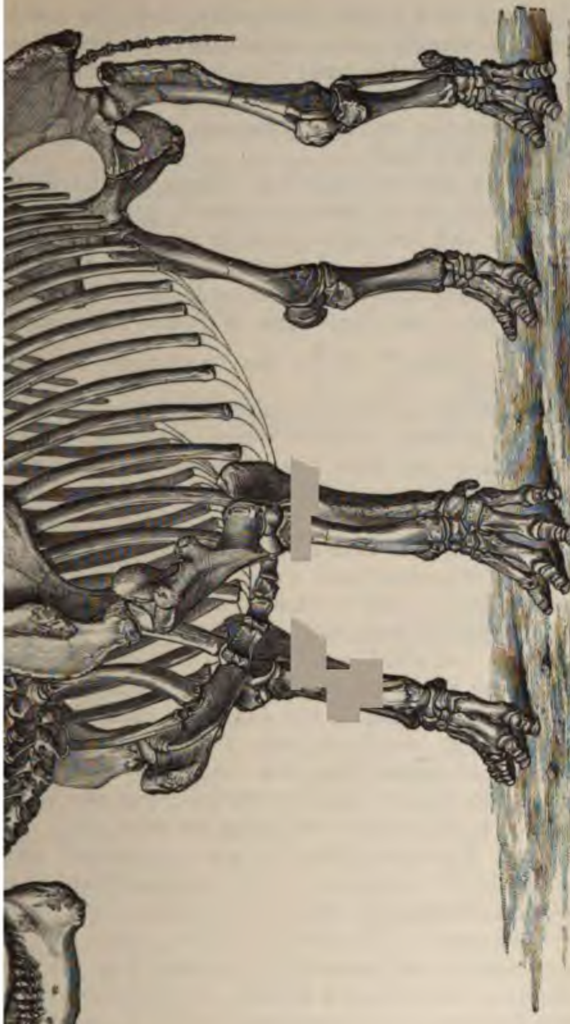


Fig. 1250.—Skeleton of *Titanotherium* (*Brontops*) *robustum*; from the Miocene of North America. $\frac{1}{24}$ natural size. (After Marsh.)

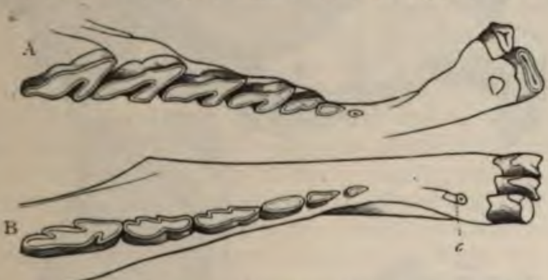
l premolars are alike, the incisors are small, and in
th a full dentition there is no diastema ; while in the
he canines are small. The cranium (fig. 1249) is

FAMILY MACRAUCHENIIDÆ.—Here may be p able family, which presents extremely generalisec vertebræ and limb-bones, such as are unknown bers of the suborder, on which account some wri not to be included in the Perissodactyla. In tl *chenia* from the Pleistocene of South Americ:

$I.\frac{3}{3}, C.\frac{1}{1}, Pm.\frac{4}{4}, M.\frac{3}{3}$; the cheek-teeth are

structure, the upper molars showing two externa surfaces and two transverse ridges; while there i diastema in the lower jaw. The cervical vertel of the *Camelidæ* in the position of their arterial articulates with the calcaneum (as in the Artio(are three digits in each foot, of which the lateral size. The incisors have a deep coronal infolding in the *Equidæ;* and Dr Hermann Burmeister thir was produced into a short proboscis. The type *chonicha;* an allied form from the infra-Pampean named by Bravard *Palæotherium paranense*, is r(meister to this genus, but has been made the genus by Dr Ameghino, under the name of *Sca* *vardi*. *M. minuta* from the same deposits is r writer the type of *Oxydontotherium;* and the n: applied to yet another form from the same area. noticed *Theosodon* from the above-mentioned (placed by Dr Ameghino in this family, although *Homalodontotherium*, which is also placed here b'

SUBORDER 3. TOXODONTIA.—This group incl very aberrant and generalised Ungulates from the America, which present affinities to the Perissoda and Rodentia, and consequently render it almost known. In *Toxodon*, of which the type species is of large nd is found in the Pleistocene of Argentina, the dental for- is $I.\ \frac{2}{3},\ C.\ \frac{0}{1},\ Pm.\ \frac{4}{3},\ M.\ \frac{3}{3}$. All the teeth (fig. 1251) grow persistent pulps; the lower canines are very minute, the inci- rge, and the crowns of both the latter and of the cheek-teeth ly curved. The structure of the latter is a simplification of an obtaining in *Nesodon*. The femur has no third trochanter, oula articulates with the calcaneum, and the cranium approxi- in some respects to that of the *Suidæ*. In the typical *T. sis* the outermost upper incisor is the larger of the two, the



.—Oral surfaces of the right upper (A) and lower (B) dentition of *Toxodon Burmeisteri*; the Pleistocene of the Argentine Republic. Much reduced. *c*, The lower canine.

e condition obtaining in *T. Burmeisteri* (fig. 1251). From the 'ampean deposits Dr Ameghino has recently described vari- mains of allied forms under the names of *Toxodontotherium*, *dontotherium*, and *Dilobodon*. A mandible from the Tertiary nte Hermosa, in Argentina, is characterised by the triangular f the third incisor, and has accordingly been named *Trigodon* Ameghino. Dr Moreno states, however, that this mandible s to the same animal as the teeth described as *Toxodontother-* id *Haplodontotherium*; and he would adopt for their owner me *Trigodon* as the one which was alone well defined.[1] The andible is peculiar in having only a single median incisor, on the line of symphysis, but this is probably an individual nality. Apparently more nearly allied to *Nesodon* (which Dr nino makes the type of a distinct family) are *Colpodon* and *odon*; while other allied remains described by the same writer he Tertiaries of Argentina under the names of *Interatherium*, *ontophanes*, and *Tembotherium*, are referred to two distinct s.

ILY TYPOTHERIIDÆ.—Perhaps still more remarkable is *Typo-*

[1] s name is really preoccupied by the earlier *Trigonodon* and *Trigonodus*.

therium (*Mesotherium*) from the infra-Pampean beds of Argentina, in which the dentition is $I. \frac{1}{2}, C. \frac{0}{0}, Pm. \frac{2}{1}, M. \frac{3}{3}$. The incisors grow from persistent pulps; and the structure of the cheek-teeth recalls that of *Toxodon*. The skull (fig. 1252) is of an Ungulate type; there is a third trochanter to the femur; and clavicles

Fig. 1252.—Skull of *Typotherium cristatum*; from the infra-Pampean of Argentina. One-half natural size.

(which are unknown in any other Ungulate) are present. This peculiar genus presents characters connecting the *Toxodontidæ* with the Rodents. Allied forms from the infra-Pampean deposits of the same region have been described as *Protypotherium*, *Stenotephanus*, and *Tomodus*; while *Pachyrucus* from the later Tertiary of Monte Hermosa is a much smaller form with three premolars.

SUBORDER 4. CONDYLARTHRA.—This group comprises a number of very generalised Ungulates mostly from the Eocene of North America, which are grouped by Professor Cope, on account of the structure of their feet, with the Hyracoidea in a division termed Taxeopoda.[1] Both the present group and the Hyracoidea are characterised by the scaphoid of the carpus being supported by the trapezoid and not by the magnum, which carries the lunar; while in the tarsus the cuboid articulates proximally with the calcaneum

[1] Professor Cope would also include the Primates among the Taxeopoda.

There is but slight mutual interlocking of the carpal and bones; the structure of these joints being simpler than in the suborders, and resembling those of the Unguiculate orders. e Condylarthra the dental formula is nearly always the typical the cheek-teeth are brachydont, and usually bunodont, although lophodont. The premolars are simpler than the true molars, may be tritubercular like those of many Carnivora; the can- and incisors frequently also recall those of that order. The rus is peculiar among Ungulates in having an entepicondylar en; the femur has a third trochanter; the astragalus, as in the ivora, presents a uniformly convex distal articular surface; and is no articular facet for the fibula either on this bone or on calcaneum. The feet usually have five digits, with sharply ed terminal phalangeals; and the radius and ulna are distinct. suborder may be regarded as containing the ancestral types which the Artiodactyla and Perissodactyla have sprung. It er presents such remarkable signs of affinity (especially in the ture of the teeth, the form of the astragalus, and the presence e foramen in the humerus) with the Carnivora, that it seems ly probable that we may look upon the Condylarthra as a side ch from the original ancestral stock of the Carnivora, which is nearly represented by the more primitive Creodonts.

AMILY PERIPTYCHIDÆ.—In this the most generalised family the ition is bunodont; the digits are five on each foot; the astra-

253.—*Periptychus rhabdodon.* Right upper (*a*) and lower (*b*) cheek-dentition, grinding ace; from the Puerco Eocene of New Mexico. Two-thirds natural size. (After Cope.)

s has no trochlea; and the premolars are very simple. In the genus *Periptychus*, from the Lowest, or Puerco, Eocene of New ico, the dental formula is $I. \frac{(2-3)}{3}$, $C. \frac{1}{1}$, $Pm. \frac{4}{4}$, $M. \frac{3}{3}$, and the ors and lower canines are small. The typical *P. rhabdodon* (fig. 1253) is characterised by its vertically grooved premolars. Other genera from the North American Eocene are *Hexodon*, *Ectoconus*, *Anisonchus*, *Hemithlæus*, *Haploconus*, and *Zetodon*; of which the fourth may be not separable from the third. From this family Dr Schlosser regards the bunodont Artiodactyla as derived, and thinks a direct relationship can be traced from *Periptychus* to *Achænodon*, and thus to the other *Chæropotamidæ*. The humerus is short, and much expanded distally.

FAMILY PHENACODONTIDÆ.—In this family the brain (fig. 1254) is characterised by the extremely small size of the hemispheres,

Fig. 1254.—Inferior, superior, and left lateral aspects of the brain of *Phenacodus primævus*; from the Lower Eocene of North America. (After Cope.)

which are only one-fourth longer than the cerebellum, and thus indicate a very low type of organisation. The family is readily distinguished from the preceding by having a proximal trochlea to the astragalus, by the longer neck, and less simple premolars, which are, however, different from those of the following family. The type genus *Phenacodus* (fig. 1255) includes several species from the Puerco and Wasatch Eocene of North America, varying from the size of a small terrier to that of a leopard. The dental series comprises the full typical number; and although the crowns of the upper true molars are of a bunodont structure, yet they could be readily modified into the lophodont type of *Hyracotherium*, and we must probably regard the latter as a direct descendant of the present genus, with perhaps the intervention of *Systemodon*. Professor Rütimeyer has described some upper molars from the Upper Eocene of Switzerland which he refers to *Phenacodus*, although they are much more of a lophodont type than in the American species.

Professor Cope remarks of one of the species of *Phenacodus* that "the size of the animal is about that of a Bull-dog, but the head is smaller,

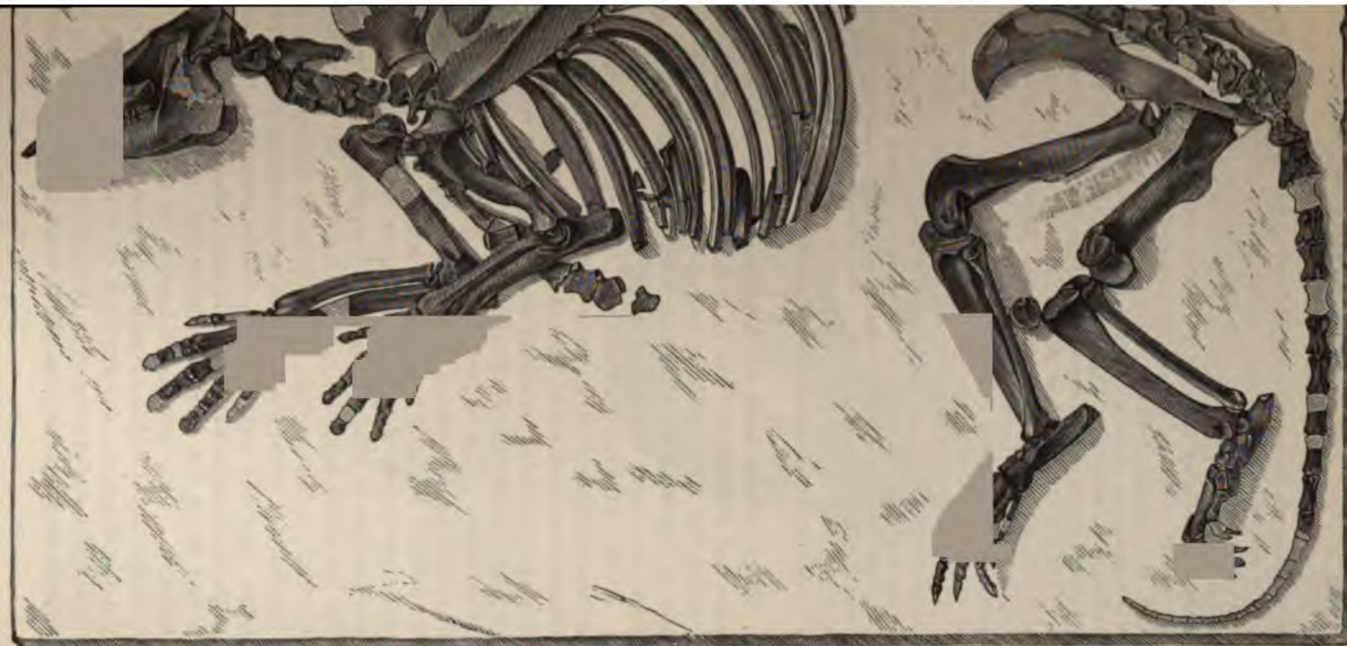


Fig. 1255.—Slab of rock showing the left lateral aspect of the skeleton of *Phenacodus primævus*; from the Lower Eocene of North America. One-seventh natural size. (After Cope.)

and the neck rather shorter and not nearly so robust. The lim about the same proportions to the body as those of a Bull-dog, anterior ones are shorter. The proportions of the parts of the lin of the fore and hind limbs to each other, excepting the feet, a as in the Collared Peccary. . . . We can thus imagine the *Ph Vortmani* as an animal of the comparatively slender build of t dog, with a head and neck proportioned more as in the Racoon, the rump more elevated than the withers, as in the Peccary. resembled those of a Tapir or Rhinoceros, but had an [additio of short toes on each foot, which did not reach the ground. To a tail much like a Cat's in proportions, and the picture is compl diet the animal was omnivorous, the proportions of animal fo smaller than the Hogs, for instance, use. The food is more likel resembled that of the Primates. What means of defence this sp is not easily surmised, as the canine teeth and hoofs are not lar

The species represented in the accompanying woodcut was dimensions; Professor Cope stating that it was intermediate i tween a Sheep and a Tapir. Comparing it to an animal with a long tail, we might perhaps take a Leopard as a fair representati remarkable length of the tail at once shows a wide difference existing Ungulates. Professor Cope, from the structure of the the nasal region, suggests that the head may have had a short

Other genera from the American Eocene are *Protogon odon*, and *Diacodexis*. The former occurs in the Puerco, and has but one outer tubercle to the fourth premolar, in plac two of *Phenacodus*. Professor Rütimeyer refers to this ger from the Upper Eocene of Switzerland.

FAMILY MENISCOTHERIIDÆ.—This family is taken to inc genera characterised by their lophodont dentition, which dently more specialised than the preceding types. By Dr they are regarded as allied to the *Chalicotheriidæ*, and perhaps indications of affinity between the European genus Hyracoidea. The humerus is longer and less expanded th *Periptychidæ*, but the number of the digits is unknown. no marked diastema in the dental series. The typical gen *cotherium* is from the Wasatch Eocene of New Mexico, an acterised by its small incisors, and the presence of two outer the last upper premolar. Teeth from the Swiss Eocene h referred to this genus. In *Hyracodontotherium*, from th Eocene of France, the upper incisors are large and curved being especially enlarged, and closely resembling the corre tooth of *Hyrax*; the canine is small, and resembles the cisor; while the fourth premolar has but a single outer tubercle. Two species are known by the skull.

SUBORDER 5. HYRACOIDEA.—As mentioned under the the Condylarthra, the structure of the carpus and tars Hyracoidea is the same as in that suborder, but the termi angeals are truncated, and there is an interlocking articul een the fibula and astragalus. This suborder is represented solely the family *Hyracidæ*, containing the two existing genera *Hyrax* g. 1256) and *Dendrohyrax*; both of which are confined to Africa d Syria, and are unknown in a fossil condition. The dental mula of the adult is $I.\ \frac{1}{1},\ C.\ \frac{0}{0},\ Pm.\ \frac{4}{4},\ M.\ \frac{3}{3}$; there are four lk-molars; the incisors grow from persistent pulps, and the pattern the cheek-teeth is of a Rhinocerotic type. The fore-feet have

Fig. 1256.—Left lateral aspect of the skull of *Hyrax capensis*. Reduced.

ree, and the hind ones four digits; and the terminal phalangeals xcept in the inner digit of the pes) have rounded hoof-like nails. he coracoid process of the scapula is well developed; there is no tepicondylar foramen to the humerus; the femur possesses a small ird trochanter; and the tibia and fibula are distinct.

SUBORDER 6. AMBLYPODA.—In this suborder, which comprises imitive Ungulates of great bulk from the Eocene of Europe and orth America, the carpus (fig. 1257, B) is characterised by the aphoid being supported by the trapezoid and not by the magnum, hile the latter and the unciform support the lunar; in the tarsus e cuboid articulates with both the calcaneum and astragalus. The rpus is therefore of a more primitive type than the tarsus. Both e carpal and the tarsal bones interlock to a slight extent (fig. 1257, c); the astragalus is flat (fig. 1257, C); the feet are short, plantiade, and furnished with five digits; and the fibula articulates with e calcaneum. The brain (fig. 1257, A) is very small in propor-on to the cranium. The cheek-dentition (fig. 1258) is of a primi-ve lophodont type; the crowns of all these teeth being very short, and the upper true molars and the hinder premolars bearing tw main oblique ridges, which usually form one or two V's. Uppe and lower canines are always present. The pelvis (as seen in fig 1260) resembles that of the Elephants in the enormous expansio and vertical position of the ilia, but is distinguished by the circum stances that the ischia do not enter into the ventral symphysi This suborder is usually divided into three sections; but a for

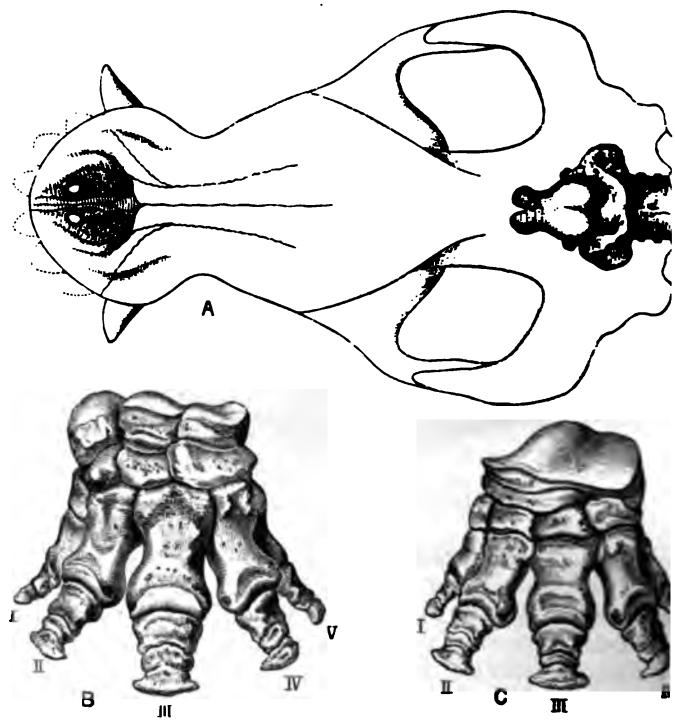


Fig. 1257.—Outline of upper aspect of cranium (A), the left manus (B[1]) and pes (C) of *Co don hamatus*; from the Wasatch Eocene of North America. A, one-fifth, B and C, on natural size.

recently discovered in the Bridger Eocene of North America, named *Elachoceros*, presents characters connecting the last two, will perhaps render it eventually necessary that they shoul abolished. Excluding this form, the characters of the three sect are as follows:—

[1] In the first row of carpal bones the one on the right of the figure i cuneiform, the central one the lunar, and that on the left the scaphoid; i second or lowest row the bone on the right is the unciform, the central or magnum, and the one on the left the trapezoid.

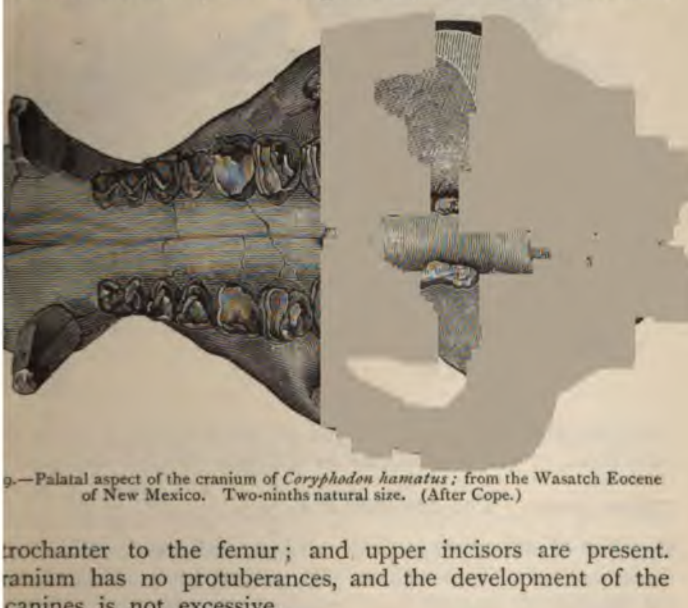
TION A. TALIGRADA.—The astragalus has a head; there is a trochanter to the femur; and superior incisors are present.

ILY PANTOLAMBDIDÆ.—The one family of this section is reted by the genus *Pantolambda*, from the Puerco, or Lowest, e of New Mexico, which presents the feature, quite unique

58.—Left upper cheek-dentition of *Coryphodon hamatus*; from the Wasatch Eocene of North America. One-half natural size. (After Marsh.)

lophodont Ungulates, of having the upper true molars with subtriangular crowns like those of the premolars of *Coryph-* ig. 1258). This is a very important feature, as showing ationship of the dentition of the Ungulata to that of the ora; and also as indicating that those Ungulates which have per premolars as complex as the true molars, are more specialan those in which the reverse condition obtains.

TION B. CORYPHODONTIA.—In this group, which Professor terms Pantodonta, the astragalus has no head; there is a



9.—Palatal aspect of the cranium of *Coryphodon hamatus*; from the Wasatch Eocene of New Mexico. Two-ninths natural size. (After Cope.)

trochanter to the femur; and upper incisors are present. ranium has no protuberances, and the development of the canines is not excessive.

FAMILY CORYPHODONTIDÆ.—The upper premolars (fig. 1258) ar simpler than the true molars, and there are frequently two V-shape ridges on the latter. The type genus *Coryphodon* was original founded by Sir R. Owen upon a lower molar from the Lond Clay; other teeth were subsequently found in the Lower Eocene

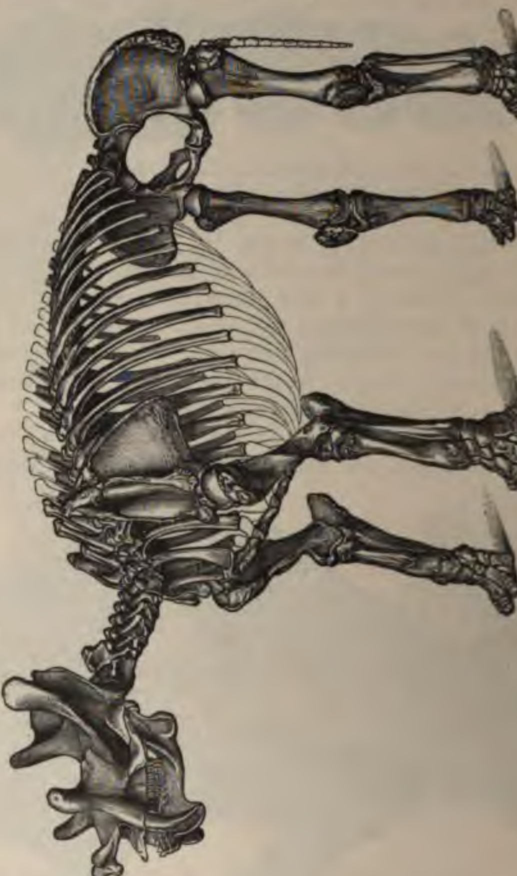


Fig. 1260.—Restoration of the skeleton of *Uintatherium ingens*; from the Bridger Eocene of Wyoming, United States. One-thirtieth natural size. (After Marsh.)

the Continent, but it was reserved for the discoveries in the hom gous strata of North America to indicate the full structure of curious genus. The dentition is $I. \frac{3}{3}$, $C. \frac{1}{1}$, $Pm. \frac{4}{4}$, $M. \frac{3}{3}$; and structure of the upper molars, cranium, and feet is exhibited in three accompanying woodcuts (figs. 1257-1259.) Other forms the Eocene of America have received the names of *Metaloph*

·hmodon, *Ectacodon*, and *Manteodon;* but further observations required to show whether all of these are really distinct from type genus.

SECTION C. DINOCERATA.—The third section of this suborder, ich Professor Marsh regards as entitled to rank as a distinct suber, is represented by the now well-known Dinocerata, which are lusively confined to the Upper or Bridger Eocene of North erica. These animals were ponderous brutes, nearly as bulky n Elephant, to which group they present many curious points of mblance. The skull (figs. 1261-1263) bears several large pro-rances; and the upper canines of the males were enormously loped (recalling those of the Feline genus *Machærodus*), and frequently protected from injury by a descending flange de-ped from the symphysis of the mandible, as is well shown in the e of the skeleton. A peculiar and characteristic feature is the absence of upper incisors; while another distinctive character e want of a third trochanter to the femur, which thus resembles corresponding bone of the Proboscidea.

AMILY UINTATHERIIDÆ.—The whole of the members of the

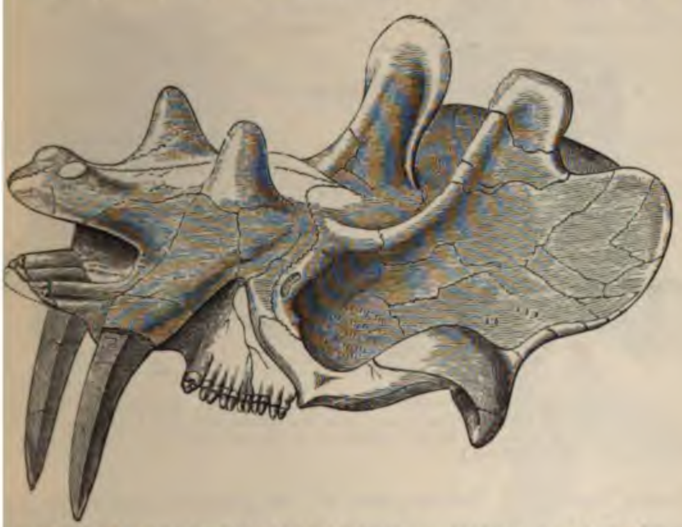


Fig. 1261.—Left lateral view of the skull of *Uintatherium mirabile;* from the Bridger Eocene of Wyoming. Much reduced. (After Marsh.)

ion may be included in this family—the equivalent of the *Tino-tidæ* of Professor Marsh. The hinder upper premolars are as plex as the true molars, and there is no distinct third lobe to last lower true molar; while in the hinder cheek-teeth of the

upper jaw the two transverse ridges unite on the inner bo
the crown to form a V; another V, with its angle directed in
occurring in the corresponding lower teeth. The least spe
genus is *Bathyopsis*, of the lower part of the Bridger Eo
which the lower canine is separated from the incisors, and
front of the upper canine in the normal manner; thus co
the more specialised forms with *Coryphodon*. Another
comparatively small size, distinguished by the absence
prominences, is apparently also entitled to generic distinct
has been named *Elachoceros*. The typical forms, acco

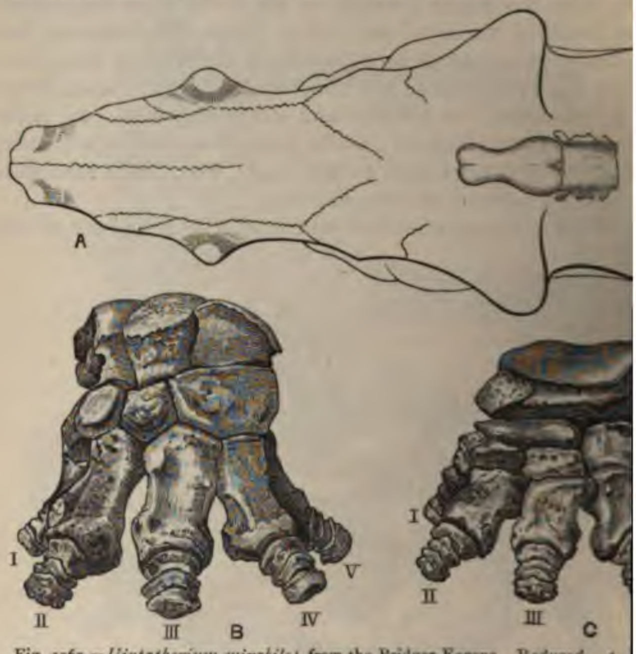
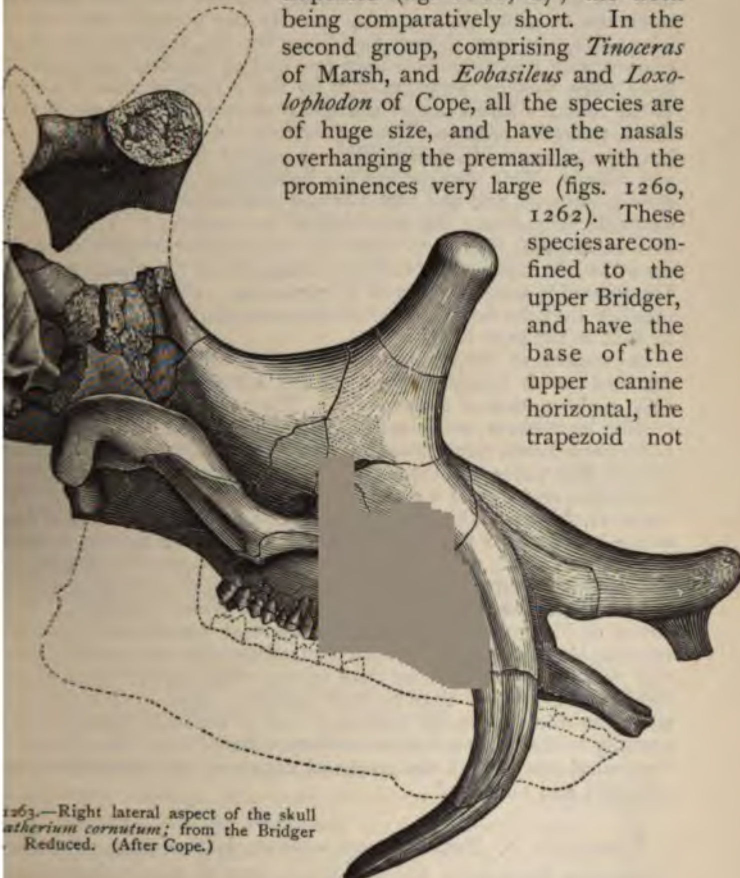


Fig. 1262.—*Uintatherium mirabile*; from the Bridger Eocene. Reduced. A,
of cranium; B, Left manus; C, Left pes. In B the middle bone of the top row
while the oval bone on the left of the second row is the trapezoid. The topmos
the astragalus. (After Marsh.)

Messrs Scott and Osborn, may all be grouped under th
name of *Uintatherium*, although they have been split up
writers into several genera under the names of *Dinoceras*,
Tinoceras, *Eobasileus*, and *Loxolophodon*. This genus ma
acterised by the presence of nasal tuberosities (fig. 126
the lower canine being approximated to the incisors, w
sembles in structure. The dental formula is usually

$\frac{3}{3}$, *M.* $\frac{3}{3}$; but according to Professor Cope the lower incisors be wanting. The genus may be divided into a *Dinoceratine* a *Tinoceratine* group. The former, which includes *Dinoceras* larsh and *Octotomus* of Cope, comprises the smaller forms from typical Bridger, in which the nasals are not greatly produced, their prominences are comparatively small (figs. 1261, 1262). rding to Professor Marsh, the base of the upper canine is cal, and the lunar has a small facet for articulation with the trapezoid (fig. 1262, B); the neck being comparatively short. In the second group, comprising *Tinoceras* of Marsh, and *Eobasileus* and *Loxolophodon* of Cope, all the species are of huge size, and have the nasals overhanging the premaxillæ, with the prominences very large (figs. 1260, 1262). These species are confined to the upper Bridger, and have the base of the upper canine horizontal, the trapezoid not



1263.—Right lateral aspect of the skull *atherium cornutum;* from the Bridger . Reduced. (After Cope.)

ating with the lunar, and the neck longer. The species, of the skull is shown in fig. 1262, is remarkable for having the

country or from the Old World. These gigantic bea
equalled the Elephant in size, roamed in great numbers
of the ancient tropical lake, in which many of them wer
lake-basin, now drained by the Green River, the mai
Colorado, slowly filled up with sediment, but remaine
that the deposits formed in it, during Eocene time, r
thickness of more than a mile. . . . At the present
lake-basin, now 6000 to 8000 feet above the sea, shows
erosion, and probably more than one-half of the depo
have been washed away, mainly by the action of th
What remains forms one of the most picturesque reg
West, veritable *mauvaises terres*, or bad lands, where
has carved out cliffs, peaks, and columns of the most
and colours. This same action has brought to light the
extinct animals, and the bones of the Dinocerata, fron
naturally first attract the attention of the explorer."
this description recalls to mind the very similar cond
cene Siwalik deposits of Northern India, where the pla
Dinocerata is taken by that of Proboscidea. The Pro
mention that the first remains of these wonderful anim
by him in the year 1870.

In respect to their structure the same writer obs
cranium "each maxillary bone carried a well-develop
ably of the nature of a horn-core. The nasals suppo
smaller horn-cores; and the frontals are developed behi
bony projections, most probably also of the nature of
animal thus possessed three pairs of horn-cores, one ca
jaw-bones, one by the nasals, and one by the frontal
however, these so-called 'horn-cores' really supported h
of the horns of the Cavicorn Ruminants, is quite a mat
and there is much probability in the view entertained b
that some of them were simply covered by callous inte

As regards the mental powers, Professor Marsh rem
cavity of *Uintatherium* is perhaps the most remarkab
remarkable genus. It proves conclusively that the b
was proportionately smaller than in any other known m
fossil, and even less than in some reptiles. It is, in fa
tilian brain in any known mammal. In *U. mirabile* th
actually so diminutive that it could apparently have be

include the largest known mammals. They present the following characteristic features; those of the soft parts being, of course, only known in the existing species. The nose is produced into a long flexible proboscis terminated by the nostrils (fig. 1264); from which feature the name of the suborder is derived. The limbs are stout, with their segments placed nearly in a vertical line (fig. 1267), and the proximal segment the longer. In the second segment the two component bones (radius and ulna in the fore, and tibia and fibula

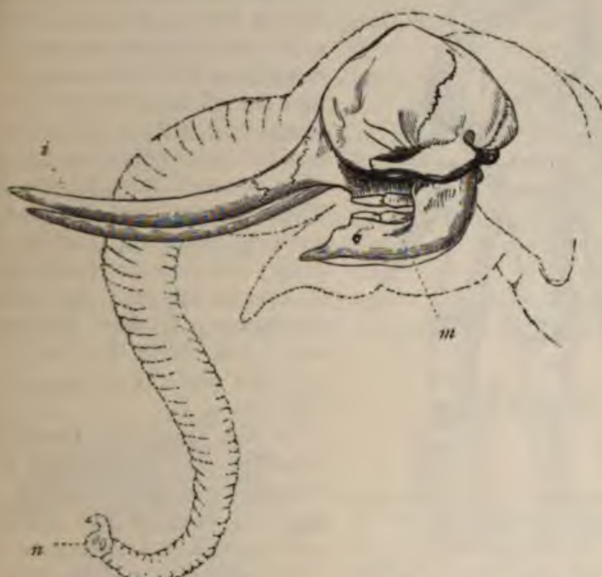


Fig. 1264.—Skull of the Indian Elephant (*Elephas indicus*). Greatly reduced. *i*, Tusk-like upper incisors; *m*, Lower jaw; *n*, Nostrils, placed at the end of the proboscis.

in the hind limb) are distinct. In the carpus the scaphoid is supported by the trapezoid, but not by the magnum, the latter supporting the lunar; while in the tarsus the cuboid articulates proximally with the distal face of the navicular, but not with the astragalus. In both the carpus and tarsus the component bones interlock but very slightly; the type of structure of the tarsus being one step in advance of that obtaining in the Condylarthra. The feet (fig. 1265) are plantigrade; there are five digits to each foot; the astragalus (fig. 1265) is flat; the femur has no third trochanter; the fibula articulates with the calcaneum; and the jugal forms the middle of the zygomatic arch. The brain is of large size; canines appear to be always absent; while incisors, growing from persistent pulps, are present either in the upper or lower jaw males of all the forms at present known. The cheek-teeth ı extreme complexity; and the true molars always consist of ridges, which may vary greatly in height, and may be eith rupted, or split up into inner and outer columns, which m more or less alternate arr there are never fewer t such ridges in the last mi first true molars; and the i valleys may be either ent or blocked by accessory t completely filled with cer toes are all invested in integument, although fun distinct broad hoofs; an digit of each foot is t There are two anterior entering the right auri heart; the stomach is sir is a large cæcum; the permanently retained in men; the uterus has t and the placenta is no and zonary.

Fig. 1265.—Dorsal aspect of the left pes of the Indian Elephant (*Elephas indicus*). Greatly reduced. (After Cuvier.) The numbers indicate the digits. The uppermost bone is the calcaneum, resting upon which is the astragalus, with its flat tibial surface. The bone with a long narrow dorsal surface immediately below the astragalus is the navicular; while the one supporting the metatarsals of the fourth and fifth digits is the cuboid.

In the skull and de members of this subor cidedly specialised; bu respects, such as the s the limbs, and the prese venæ cavæ, they show ralised features; and th wanting indications of affinity with the Rodent haps the Sirenia. It wi as we proceed that the structure of the cheek-dentiti vanced from a comparatively generalised type in *Din* an extremely specialised one in the existing species of and it appears that this specialisation "has followed to able extent a line analogous to that obtaining in the Pe and Artiodactyla, and shows itself in the increased heigl plexity of the crowns of these teeth and in the final atta nearly horizontal and continuous plane of wear. From t of the cheek-teeth in the more generalised members of t it may be inferred that the action of the molars of or those of the other must have been mainly a scissor-like while in the more specialised forms this action has been con-ed into a perfect grinding motion."[1]

he pelvis of the Proboscidea is characterised by the vertical tion and great expansion of the large ilia, and the very small of the ischia and pubes, both of which enter into the formation e very short symphysis.

ie Proboscidea make their first appearance in the Middle Mio-(Sansan stage) of Europe; but we are still unacquainted with orm which connects them decidedly with the other suborders e Ungulata, although *Dinotherium* affords an inkling of how a transition may have taken place. The Mastodons prob-originated in Europe, from whence they travelled to India, there gave origin to the peculiar Stegodont group of Ele-s, which are the parents of the existing specialised forms. the eastern regions of the Old World it seems probable the higher Elephants travelled back to Europe, while they eached North America in the Pleistocene epoch; Mastodons g arrived in the New World during the preceding Pliocene l.

MILY DINOTHERIIDÆ.—This family is at present known solely e genus *Dinotherium*, of which the remains are found in the

1266.—Skull, and lateral (A) and oral (B) aspects of the first lower true molar of *Dino- giganteum*; from the Upper Tertiary of Europe. All the figures are reduced; the n of B being less than that of A.

ene and Pliocene of Europe and India. The type species is *ganteum* (fig. 1266), originally described by Cuvier, upon the nce of a molar tooth from the Middle Miocene of the Orlean- as a gigantic Tapir, but better known by the cranium and

[1] uoted from the writer's 'Catalogue of Fossil Mammalia in the British m,' pt. iv., from which other extracts have already been made.

which there are three in the first tooth of the seri
and two in each of the others. The upper pr
the true molars in having their two transverse r
the outer side by a longitudinal ridge, which cau
be of the lophodont type of those of the Tap
animal there were three milk-molars in each ja
the true molars in structure; each of the first t
transverse ridges, while the third has three of the
resembles the first true molar. The number
milk and true molars may therefore be represe

Mm. $\frac{2 \cdot 2 \cdot 3}{2 \cdot 2 \cdot 3}$, *M.* $\frac{3 \cdot 2 \cdot 2}{3 \cdot 2 \cdot 2}$; the import of whi
under the head of the *Elephantidæ*. *Dinother*
the Upper Miocene and the Lower Pliocene
India, was probably nearly allied to the Europ

FAMILY ELEPHANTIDÆ.—With this family we
animals in which the succession of the cheek-t
marked peculiarities as to require special notice
the existing members there are normally six of
increase gradually in size and complexity from
The last three of these teeth correspond to the
aberrant Ungulates, while the anterior ones repr
milk-molars of the same. These milk-teeth are
premolars, but the whole series of teeth is gradua
in the jaw; the anterior teeth being worn aw
absorbed before the hinder ones come into use
of this arrangement, and the large absolute size
are never more than portions of two cheek-tee
each jaw in use at any one time, as is shown
cheek-teeth of the existing Elephants will there
Mm. 2 + *Mm.* 3 + *Mm.* 4 + *M.* 1 + *M.* 2 + *M.* 3 o

nple marsupial dentition known in the whole class. In some se fossil forms in which the structure of the cheek-teeth is r, there may be portions of three such teeth in use at the time. The serial position of individual teeth in any one s can be more or less exactly determined by their absolute nd the number of transverse ridges which they carry. In all ers of the family there are never less than three ridges in the milk-molar and the first and second true molars (which are collectively spoken of as the "intermediate molars"), while st true molar has one or more ridges in excess of the preced- ooth. Incisors are always present in the upper jaw of male iduals, and may or may not be also developed in the lower In transverse section the dentine of these teeth displays a iar arrangement of decussating lines, similar to the "engine- ng" on the back of a watch-case, by the presence of which true can always be recognised.

e earliest and least specialised genus of this family is *Mastodon*,[1] ich premolars and lower incisors are frequently present, and

. 1267.—Restoration of the skeleton of *Mastodon angustidens*. Greatly reduced. (After Gaudry.)

pper incisors may have longitudinal bands of enamel. The teeth carry transverse ridges, which may be entire or may be d into distinct inner and outer columns with a more or less

fessor Cope proposes an arrangement of the *Elephantidæ* differing from generally adopted. Thus the genus *Mastodon* is split up into *Tetrabel-* which there are both upper and lower tusks, and the former have an -band; *Dibelodon*, in which the lower tusks are usually wanting, but er ones have an enamel-band; and *Mastodon*, in which there are no lower nd no enamel-band on the upper ones. *Elephas* is divided into *Emmen-* ypically represented by *Elephas Clifti* (apparently the type of *Stegodon*), including *E. planifrons*, and characterised by the presence of premolars; *ephas*, which is taken to include all the other species.

alternate arrangement; outlying tubercles may be present in th intervening valleys, which are frequently entirely devoid of cemen and are never completely filled by it. All the "intermediate" mola usually have the same number of ridges; this number varying fro three to five. The ridges are always bisected by a median cle traversing the long axis of the crown; and the plane of wear of th crowns of the teeth is oblique, that of the upper jaw inclining fro

Fig. 1268.—*Mastodon angustidens.* The fourth left lower milk-molar; from the Lower Siwaliks of India.

the outer to the inner side, and the reverse obtaining in the low Three cheek-teeth may be in use at the same time, and the sy physis of the mandible may be greatly elongated. The vertex the cranium (fig. 1267) is usually but slightly elevated, as in majority of Ungulates; and in the less specialised forms (as may seen by comparing fig. 1267 with fig. 1270) the proportions of

Fig. 1269.—*Mastodon angustidens.* Vertical longitudinal section of the first lower true m from the Middle Miocene of France. Two-thirds natural size. *b*, Enamel; *e*, Dentine. Gaudry.)

entire skeleton depart less widely from the same type. The g has been divided into two groups, according to the number of ri in the cheek-teeth. In the first or *Trilophodont* group, the num of complete ridges in each of the three "intermediate" mola three (fig. 1268); the ridge-formula of the complete series of ch

eth being represented by the ciphers *Mm.* $\frac{1 \cdot 2 \cdot 3}{1 \cdot 2 \cdot 3}$, *M.* $\frac{3 \cdot 3 \cdot 4}{3 \cdot 3 \cdot 4}$.
will be noticed that in this section the number of ridges in the ird and fourth milk-molars and the first true molar is the same as *Dinotherium*.

One of the earliest examples of this group is *M. angustidens* from the gher Miocene of both Europe and India, of which two lower cheek-eth are represented in plan and section in figs. 1268 and 1269. The mple structure of these teeth is shown in the section, where the valleys parating the low, interrupted ridges, are seen to be devoid of cement, though partially blocked by outlying tubercles. The imperfect fourth dge at the hinder extremity (right side of figures) of these teeth is rmed the *talon*. The mandibular symphysis (fig. 1267) in this species as elongated and furnished with a pair of incisors; while the milk-olars were succeeded by premolars. Allied to this species are *M. pan-onis* of the Upper Miocene and Pliocene of India, and *M. pentelici* of

Fig. 1270.—Skeleton of *Mastodon americanus*; from the Pleistocene of Missouri. Much reduced.

e Lower Pliocene of Attica, Hungary, Samos, and Persia. From *M. gustidens* there is but a step to the contemporaneous European *M. ricensis*, in which the ridges of the molars extend straight across their owns, without outlying tubercles in the valleys; and from this species, ain, the transition is easy to the Pliocene *M. Borsoni* of Europe, in ich the mandibular symphysis has become shortened in conse-ence of the absence of lower incisors. A later offshoot from the same anch is found in *M. americanus* (frequently known as *M. giganteus*, or *ohioticus*) of the Pleistocene of North America. Remains of th species (figs. 1270, 1271) are exceedingly abundant in the celebrat "Big-Bone-Lick" of Kentucky, in which region the species survived in the human period. Although the mandibul symphysis is short, a single small incisor occasionally found on one side of the ja premolars had however disappeared.[1] Oth Trilophodont species are *M. Humboldti* a *M. cordillerum* (*andium*) of the Pleisto of South America, in both of which the tra verse ridges of the cheek-teeth are bro into columns. The former species is dis guished by the short and edentulous s physis of the mandible. According to Falconer, the latter had an elongated man ular symphysis and large lower incisors; Dr Burmeister states that this referenc incorrect, and that the symphysis was s and tuskless.

Fig. 1271.—Outer view of second left lower true molar of *Mastodon americanus.* Reduced.

In the *Tetralophodont* group the n ber of ridges in the cheek-teet greater than in the former group, there being usually fou the "intermediate" and five in the last true molars; but may be occasionally five in the former and six in the latter. complete normal ridge-formula is, therefore, *Mm.* $\frac{2-3-4}{2-3-4}$, *M.* $\frac{4-}{4-}$

In this group *Mastodon arvernensis*, from the Upper Plioce Europe, is characterised by the number of accessory tubercles o

Fig. 1272.—*Mastodon arvernensis*; the fourth left upper milk-molar; from the Norwich Crag. (After Lyell.)

crowns of the cheek-teeth (fig. 1272) and the somewhat alternate arr ment of the inner and outer columns of their transverse ridges, by

[1] It appears probable that these teeth may occasionally be developed abnormality.

the transverse valleys become more or less completely blocked. allied to this species is *Mastodon sivalensis*, of the Pliocene of rn India, of which a last upper true molar is represented from the aspect in fig. 1273; in this species there are occasionally five

. 1273.—Profile view of last upper true molar of *Mastodon sivalensis*; from the Pliocene of the Siwalik Hills of India. Reduced.

n the "intermediate" molars, and the last upper true molar (as in re) may have six ridges and a hind talon; the blocking of the by the alternate arrangement of the inner and outer columns of es is well exhibited in the woodcut. Both in this species and *M. nsis* the symphysis of the mandible is short and tuskless, as in the modern Elephants; and the Siwalik species is further characterised by the great elevation of the vertex of the skull (fig. 1274), in which respect it also agrees with the last-named group. Both these species must be regarded as highly specialised forms which have diverged from the line connecting the *Trilophodont* group with the true Elephants. We may here briefly mention *M. perimensis* and *M. punjabiensis* of the Indian Pliocene, which show certain characters intermediate between the two above-mentioned species and *M. longirostris*, which we now proceed to notice. The last-named species occurs typically in the Lower Pliocene bone-sand of Eppelsheim in Hessen-Darmstadt, but has lso found in the English Red-Crag. It has an elongated mandi- ymphysis furnished with a pair of short incisors (fig. 1275), and

74.—Left lateral view of the skull of *sivalensis*; from the Siwalik Hills of reatly reduced. (After Falconer and

Fig. 1275.—Left lateral view of the imperfect skull of *Mastodon*
Bone-sand of Hessen-Darmstadt. Much reduced. (A

would follow the fourth milk-molar (the right-hand
each have the same number of ridges as the latter.
Pliocene of Western India, is a form connecting the
latidens. The latter is very widely distributed, rang

hat there is really no distinction between that genus and *Mastodon*, lthough the retention of the latter term for the more generalised forms f what would be otherwise a very unwieldy genus is convenient.

1277.—Crown surface of the third left upper true molar of *Mastodon latidens*; from the Pliocene of Borneo. Two-thirds natural size.

h the above-mentioned proviso as to its apparent passage into odon we may note the chief features of the existing genus *Elephas*.

1278.—Palatal view of the mandible of the Indian Elephant (*Elephas indicus*). Greatly d. The hinder portion of the penultimate and the anterior half of the last true molars are

s lower incisors (tusks) are invariably wanting; the enamel on upper incisors merely forms a small cap at their extremities;

premolars are nearly always absent; while the mandibular symphysis is never produced into a long rostrum, but usually terminates in a short spout-like channel, as in fig. 1278. The ridges of the true molars extend straight across their crowns, and generally show no sign of division into inner and outer columns; there is always a certain quantity of cement in the valleys between the ridges; and in those species in which these ridges become developed into tall thin plates, the cement forms equally tall laminæ filling the intervening spaces. In the least specialised forms the number of the ridges in the "intermediate" molars may be as low as five; while those in the last true molar may vary from seven in the least specialised to upwards of twenty-four in the most specialised species. Finally, it is only in a few of the more generalised species that the "intermediate" molars have an isomerous ridge-formula.

Like the Mastodons, this genus is divided into two groups according to the structure of the teeth. In the first, or *Stegodon* group, which is entirely confined to the Eastern parts of the Old World, the number of ridges in the cheek-teeth is comparatively low, and there may be only five or six of such ridges in the "intermediate," and from seven to eleven in the last upper true molars.

The structure of the molars of *Elephas Clifti*, from the Pliocene of India, Burma, and Japan, which is the most generalised species of the

Fig. 1279.—*Elephas Clifti*. The first left upper true molar; from Burma. One-half natural size. (After Clift.)

genus, is shown in fig. 1279; where it will be seen that the ridges are and roof-like, and that the cement is confined to the bottom of the intervening valleys. The molars of this species (in which premolars w developed), it will be seen, are but one step in advance of those of Tetralophodont Mastodons. In other species of this group, like *E.*

signis, the ridges of the molars (fig. 1280[1]) become more numerous, and somewhat higher; while the intervening valleys are more or less completely filled with cement. The number of ridges in the cheek-teeth of this species may be represented by the formula *Mm.* $\frac{2 . (5-6) . 7}{2 . 5 . (7-9)}$, *M.* $\frac{(7-8) . (7-8) . (9-11)}{(7-10) . (8-12) . (9-13)}$. Allied species are *E. bombifrons* and *E. ganesa*, which are found in the Pliocene of India and the countries to the eastward as far as Japan.

In the second, or *Elephantine*, group, the specialisation of the molars becomes greater; in all the species the ridges are so tall that they assume the appearance of plates, but there is great varia-

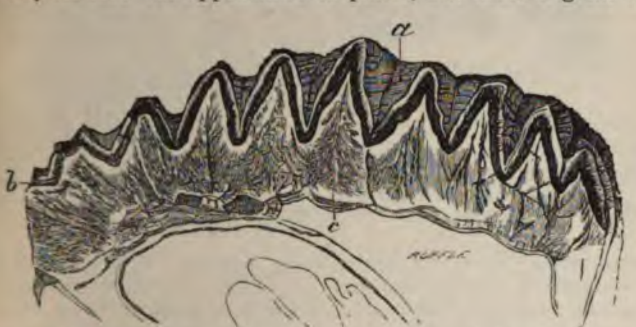


Fig. 1280.—*Elephas insignis*. Vertical and longitudinal section of the third left upper true molar; from the Pliocene of the Siwalik Hills. One-third natural size. *a*, Cement; *b*, Enamel; *c*, Dentine. (After Falconer and Cautley.)

tion in respect to their height and number; those of the less specialised forms not being more numerous than in *E. insignis*. The cement always completely fills the interspaces between the ridges, and in the higher forms these interspaces are extremely narrow.

One of the least specialised members of this group is *Elephas planifrons*, from the Pliocene of Northern India, of which the section of an upper molar is represented in fig. 1281. In the teeth of this species the number of the ridges is nearly the same as in *E. insignis*; but, as will be seen from the figure, the ridges have become much taller and thinner, and the valleys are completely filled up with cement. It results from this structure that when the crown of the tooth has become well worn (as in the anterior half of fig. 1282), its grinding aspect will present a nearly flat surface marked by a series of transversely elongated raised disks of enamel, each enclosing an islet of dentine. This structure, which is still better exemplified in the more-worn molar of the closely allied *E. meridionalis* (fig. 1283), of the Upper Pliocene of Tuscany and the Norfolk "Forest-bed," is admirably adapted for the attrition of vegetable matter owing to the inequalities produced on the surface, due to the variation in

[1] In this figure, as well as in fig. 1281, the tooth is turned the wrong way upwards.

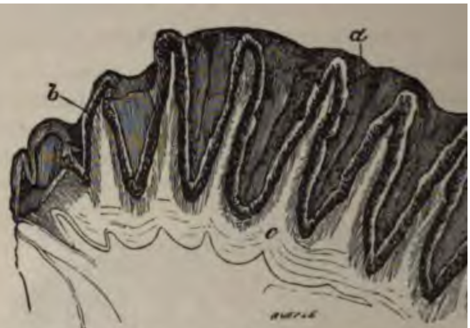


Fig. 1281.—*Elephas planifrons.* Vertical and longitudinal sectio
molar; from the Pliocene of the Siwalik Hills. One-third natural si
(After Falconer and Cautley.)

of some individuals of the former being estimated
feet, while a fair average height of males of the exist
not greater than nine feet. *E. planifrons* is rema
only member of the Elephantine group in which pr
oped. Somewhat more specialised, both in regard
number of the ridges of the cheek-teeth, and also in
vertex of the cranium, is *E. hysudricus*, of the Plioce
which may perhaps have been the ancestor of the

Fig. 1282.—Grinding surface of upper molar of *Elephas planifron*
from the Pliocene of India. (After Falconer and C

median expansion of the worn enamel-disks of the ridges, which thus approach a lozenge-shape. The range of this species in England does not extend northwards of Yorkshire, and it goes as far south as Algeria,

Fig. 1283.—Upper molar of *Elephas meridionalis*, one-third natural size; from the Upper Pliocene of Tuscany.[1]

where the allied *E. atlanticus* is also found. From the molars of *E. antiquus* there is but a step to those of the existing African Elephant (fig. 1285), in which the enamel-disks assume a still more decided lozenge-

Fig. 1284.—The second right lower true molar of *Elephas antiquus*; from the Pleistocene of England. One-third natural size.

shape; and the small *E. mnaidriensis* and *E. melitensis*, of the Pleistocene cavern and fissure-deposits of the Maltese and neighbouring islands, are more or less closely allied forms. The height of the smallest indi-

Fig. 1285.—A right upper true molar of *Elephas africanus*: Recent. Africa. One-third natural size.

viduals of the last-named, or "Pigmy Elephant," is estimated as not greater than three feet. Another peculiar Elephant is *E. namadicus*, from the Pleistocene of the Narbada Valley, in Western India, and Japan,

[1] The hinder part of this tooth is to the left; the position of the preceding figure being the reverse.

which is closely allied in dental characters to *E. antiquus*, although
guished by a very prominent overhanging ridge on the frontals.
we may also mention *E. Columbi*, of the Pleistocene of Cent
North America, and *E. armeniacus* from Armenia; the forme
intermediate in the structure of its teeth between *E. antiquus* and
cus, and the latter between *E. primigenius* and *E. indicus*. It is, h
not improbable that *E. Columbi* is only a variety of the Mammoth.

Fig. 1286.—A half-worn third left upper true molar of the Mammoth (*Elephas*
viewed from the grinding surface; from the Pleistocene of Europe. One-third n

we have the Mammoth (*E. primigenius*), in which the numbe
in the molars is represented by the high figures *Mm.* $\frac{(3\text{–}4).(6\text{–}}{(3\text{–}4).(6\text{–}}$

M. $\frac{(9\text{–}15).(14\text{–}16).(18\text{–}27)}{(9\text{–}15).(14\text{–}16).(18\text{–}27)}$. "The incisors are usually long,
not very thick near the alveolus; they are, however, subjec
variation. The molars (fig. 1286) are relatively wide in pro
their length; their ridges a
and closely packed, with th
enamel, and dentine very
plication of the enamel
slight; the worn dentine-
very narrow; and the crown
characterised by the extren
of its wear. Variations are
and those molars in which
are thicker and less nume
the enamel is more plicated,
very closely to certain ex
E. antiquus. The existin
species presents a close ap
dental and skeletal structur
molars are decidedly of a le
ised type, and thereby ind
the living species is not a d
of the Mammoth." This a
covered with a thick woolly
also with an outer coverin
hair, by which means it was
from the climatal rigours of

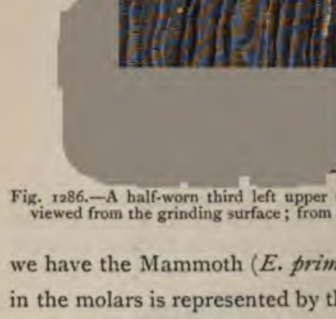


Fig. 1287.—Lateral view of a half-worn upper true molar of the Mammoth. About one-third natural size.

erly regions over which it once roamed. Remains of the Mamr
been found in Northern Europe, Asia, and America; and in
soil of the banks of the Siberian rivers numerous carcasses h

l with the dried flesh, skin, and hair preserved; the skeleton of of these specimens, with portions of the skin still adhering to it, g preserved in the Museum at St Petersburg (fig. 1288). The nmoth was essentially northern in its distribution, apparently not ing southwards of a line drawn through the Pyrenees, Alps, the

Fig. 1288.—Skeleton of the Mammoth. Greatly reduced. Portions of the integument still adhere to the head, and the thick skin of the soles is still attached to the feet.

ern shores of the Caspian, Lake Baikal, Kamschatka, and the vi Mountains. Its remains occur in the Norfolk "Forest-bed," om this date the species existed right through the glacial epoch, as well known to the primitive human inhabitants of Northern e, as is testified by its portrait drawn on a fragment of its own by one of these early hunters.

Finally, it should be mentioned that a portion of a tusk of a Proboscidean, said to have been obtained from the Pleistocene of Australia, has been described as *Notelephas*. There are, however, no characters in this specimen to indicate its right to generic distinction, and its reputed origin must be looked upon with great suspicion.

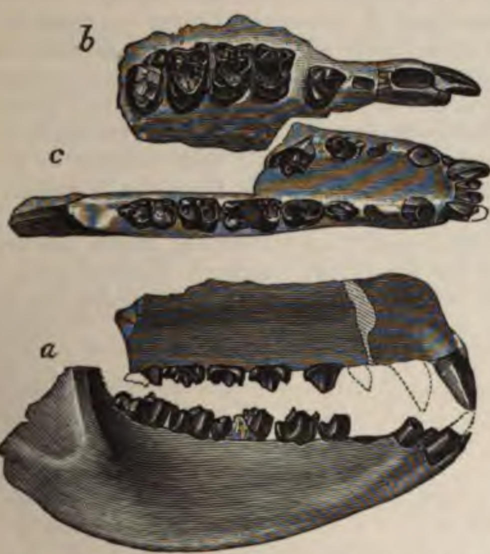
GROUP TILLODONTIA.—Here may be noticed a remarkable group of Mammals from the Lower Eocene, of which the position is still unsettled. They are regarded by Professor Marsh as constituting a distinct order; while Professor Cope subdivides them into Tillodontia and Tæniodontia, and includes them in his order Bunotheria. A suggestion has also been made of affinity with the Edentates. These Mammals, as will be gathered from the characters mentioned below, present certain characters common to the Ungulata, Rodentia, and Carnivora, but to include them in either one of those orders would render it impossible to give anything approaching to a definition of the order so enriched. Putting aside the suggestion of Edentate affinities as requiring further evidence, the characters presented by the Tillodonts harmonise with the view that both the Ungulates and Rodents have been derived from a primitive Carnivorous stock.

FAMILY ANCHIPPODONTIDÆ.—The genus *Anchippodus* (*Trogosus*) with which *Tillotherium* (fig. 1289) is closely allied or identical, is

Fig. 1289.—Left lateral aspect of the skull of *Tillotherium fodiens*; from the Lower Eocene of North America. One-fourth natural size. (After Marsh.)

from the Lower Eocene of North America, and apparently has the dental formula $I. \frac{2}{2}$, $C. \frac{1}{1}$, $Pm. \frac{3}{4}$, $M. \frac{3}{3}$. The lower cheek-teeth mble those of *Palæotherium*, but the upper true molars are of triangular tritubercular type. The first pair of incisors is l, but the second is large and scalpriform, with persistent s like the incisors of the Rodents. In many respects the eton approximates to that of the Creodonta; the femur has a l trochanter; the feet were five-toed, with the whole sole applied ie ground, and having ungual phalanges similar to those of the s. The brain-cavity is of small size, and the cerebral hemi-res did not extend over the cerebellum or the olfactory lobes. orbits are not complete, but open into the temporal fossæ. icles were probably present.

AMILY PLATYCHŒROPIDÆ.—The type genus of this family is *ychærops* (*Miolophus*), from the London Clay, to which the



1290.—*Esthonyx Burmeisteri*.—The palate and mandible; from the Wasatch Eocene of ing, U.S.A. Two-thirds natural size. *a*, Lateral view of part of cranium and mandible; view of right half of palate; *c*, Oral view of mandible. (After Cope.)

h American *Esthonyx* (fig. 1290) appears to be allied. In the the first upper and the second lower incisors are scalpriform, do not grow from persistent pulps; the dental formula is *C.* $\frac{1}{1}$, *Pm.* $\frac{3}{3}$, *M.* $\frac{3}{3}$ If *Esthonyx* be not allied to *Platychæ-* the former must constitute the type of a family, which should nown as the *Esthonychidæ*. The genus *Psittacotherium*, of h the family position is uncertain, has the mandible of great

FAMILY CALAMODONTIDÆ.—In *Calamodon*, the
this family (the Tæniodontia of Professor Cope),
resembles that of *Psittacotherium ;* there are three
of which the second and third are scalpriform,
anterior surfaces faced with enamel; and the chee
in number, but cannot be differentiated into pren
molars. There is no diastema, and the cheek-tee
to those of the Rodents in their massive squared c
also been considered to show resemblances to thos
tates. The second lower incisor is much larger tha
others, and the mandibular condyle is transversely e
fessor Cope, as will be noticed below, regards this
especially *Psittacotherium*, as close to the ancestr
Rodentia, and has also suggested their alliance t
of the Edentates; *Calamodon* is from the Wasa
Eocene.

FAMILY STYLINODONTIDÆ.—Professor Marsh ha
family name for the North American Tertiary ge
in which the molars grew from persistent pulps li
Edentates.

CHAPTER LXII.

CLASS MAMMALIA—continued.

ORDERS RODENTIA AND CARNIVORA.

ORDER VII. RODENTIA.—The Rodents form one of the best-defined orders of the whole class, and are readily characterised by the absence of canines, and their chisel-like (scalpriform) incisors (of which there is only a single lower pair), separated by a long diastema from the cheek-teeth (fig. 1298), and of which generally only the anterior face is coated with enamel. The dentition is diphyodont and heterodont; the incisors grow from persistent pulps, and the cheek-teeth may be either rooted or rootless. The crowns of the latter are entirely adapted for grinding, and are very frequently (fig. 1292) complicated by deep infoldings of enamel. The premolars are very generally either $\frac{1}{1}$ or $\frac{0}{0}$, and the true molars $\frac{3}{3}$. The premaxillæ are large; the zygomatic arch is complete, the middle portion being generally formed by the jugal; the orbit is confluent with the temporal fossa; there is a long diastema; and the condyle of the mandible is antero-posteriorly elongated, and, through the absence of a postglenoid process in the cranium, capable of a backwards and forwards motion. The feet are generally partially or entirely plantigrade, and usually furnished with five unguiculate digits. More or less complete clavicles are present, and the acromion of the scapula frequently has a long recurving process. All the existing forms are of comparatively small size, and most of them are of terrestrial habits. The feature of hypsodontism, which we have already noticed under the head of the Ungulata, attains its greatest development in this order; its final stage being the production of rootless cheek-teeth.

That the Rodents are connected in some manner with the more

resemblance to *Typotherium* among the Toxodo
entire order distant affinities are indicated to the
shown by the characters of the teeth, the acromio
and the position of the jugal.[1]

This order is well known from the period of tl
(Oligocene), while *Decticadapis* apparently carrie
commencement of the Tertiary. It has not sufi
by the extinction of family types at the present
the gigantic forms have completely disappeared.

SUBORDER I. DUPLICIDENTATA.—This suborde
by the number of the incisors, which in the adult
$\frac{3}{1}$. The outer pair of upper incisors is very soon
pair being of small size, and placed directly behi
pair. The incisive palatal foramina are large an
fibula is anchylosed to the tibia, and articulates wi
The enamel-coat of the incisors is not entirely
anterior surface.

FAMILY LEPORIDÆ.—In this family the number
Pm. $\frac{3}{2}$, *M.* $\frac{3}{3}$; these teeth being rootless, with tr
folds. The clavicles are imperfect, and the fore li
the hind ones. This family includes at the pres
cosmopolitan genus *Lepus*, comprising the Har
Existing species of that genus have left their rem
of Europe and Brazil; while extinct ones are fou
Pliocene of France (*L. Lacosti*), in the Siwaliks of
John Day Miocene of North America. *Palæolag*
cene of the latter country is closely allied to *Lepus*
from equivalent strata in New Mexico has only a s

FAMILY LAGOMYIDÆ.—This family includes very small Hare-like Rodents, with short ears, complete clavicles, and the fore limbs not shorter than the hinder. They are very characteristic of the mountains of Central and Northern Asia, but also occur in those of Europe and North America. Their cheek-teeth resemble those of *Lepus*, but the premolars are never more than $\frac{2}{2}$, and may be reduced to $\frac{1}{1}$. Those extinct forms in which the premolars are $\frac{2}{1}$ have been separated from the existing genus *Lagomys* as *Myolagus*, and those with only *Pm.* $\frac{1}{1}$ as *Titanomys*, but it appears preferable to include all these variations in the type genus. The Pleistocene of Europe contains remains of some existing and some extinct (*L. sardus*) species, and the genus is well represented in the Tertiaries of the Continent as far down as the Lower Miocene (Upper Oligocene); the species of the latter horizon being *L. visenoviensis* (fig. 1291), the type of *Titanomys*. Fossil remains of this genus have also been found in the Pleistocene cave-deposits of Port Kennedy in the United States.

Fig. 1291.—Left ramus of the mandible (outer view) of *Lagomys visenoviensis*; from the Lower Miocene of Europe.

SUBORDER 2. SIMPLICIDENTATA.—The incisors are always $\frac{1}{1}$, and have the enamel confined to their anterior surface. The incisive foramina on the palate are of moderate size; and the fibula does not articulate with the calcaneum.

FAMILY CAVIIDÆ.—This and the following five families compose the section *Hystricomorpha*. The *Caviidæ*, which are now exclusively confined to America, have four anterior and three posterior digits, and in the existing genera the crowns of the molars are divided by enamel-folds into transverse lobes; the number of the cheek-teeth being *Pm.* $\frac{1}{1}$, *M.* $\frac{3}{3}$. *Cavia*, in which the tail is absent, is represented by remains of several existing species in the Pleistocene of the Brazilian caves; while *Contracavia* is a much larger extinct type from the infra-Pampean of South America. *Microcavia*, again, from the Pleistocene of Argentina, presents characters connecting it with *Cavia* and the following genus. *Dolichotis* (or *Cerodon*), in which there is a short tail, is also represented in the South American Pleistocene; two species being extinct, while the third (*D. antiqua*) may be identical with the living form. Here may be provisionally placed the genera *Issiodoromys* and *Nesocerodon* from the Quercy Phosphorites and Lower Miocene of France, which are regarded by recent authorities as related to *Dolichotis*, although formerly placed in the *Theridomyidæ*. The crowns of their molars are vertically divided by enamel-folds into two heart-shaped lobes. *Hydrochœrus*—the largest living Rodent—is represented in the Brazilian cave-deposits by a species probably identical with the living Capybara, and also in the Pleistocene of Buenos Ayres by an extinct one estimated to have attained a length of five feet, and by a third (*H. magnus*) of still larger dimensions. An extinct species has also been obtained from the Pleistocene of South Carolina; and another from the infra-Pampean deposits of Parana. From the latter deposits other forms supposed to be more or less nearly allied to the existing genus have received the names *Cardiatherium*, *Procardiatherium*, *Cardiomys*, and *Cardiodon;* the latter name had, however, been previously applied to a Sauropodous Dinosaur,[1] and is therefore inadmissible.

FAMILY DASYPROCTIDÆ.—In this South and Central American family the number of the cheek-teeth is the same as in the last; and these teeth are also semi-rooted, but their crowns have external and internal enamel-folds (fig. 1292); and the incisors are long. The type genus *Dasyprocta* is represented by numerous forms in the Pleistocene of the Brazilian caves; while a *Cœlogenys* occurring in the same deposits is probably identical with the living Paca (*C. paca*).

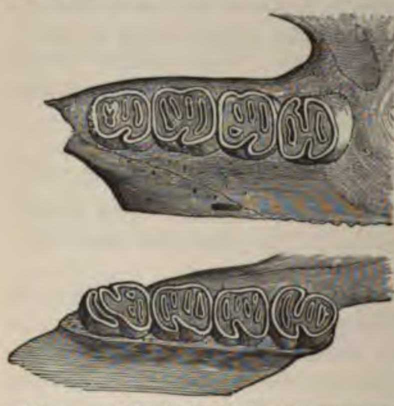


Fig. 1292.—Palatal view of the right upper and lower dentition of *Dasyprocta*. Recent. America. The tooth in each jaw on the right side of the figure is the premolar.

FAMILY CHINCHILLIDÆ.—This third family of American Rodents has the same dental formula as the last, but the molars have continuous enamel-folds extending completely across their crowns, and the hind limbs are much elongated. The genus *Lagostomus* is represented in the South American Pleistocene by the existing Vischaca (*L. trichodactylus*), as well as by some extinct forms. *Megamys* from the infra-Pampean deposits of Patagonia and Parana is the largest representative of the order yet known; its bulk being estimated as equal to that of an Ox. Several species have been described, one of which is the type of *Potamarchus* of Dr Burmeister. Allied genera from the South American

[1] See page 1177.

ts are *Epiblema* and *Tetrastylus;* one species of the latter : been originally referred to *Theridomys.*

ILY HYSTRICIDÆ.—The Porcupines are well characterised by piny covering. The number of their cheek-teeth is the same the preceding families; and these teeth have both external nternal enamel-folds. An extinct species of the American *Synœtheres* occurs in the Pleistocene of the Brazilian caves, a species of the other American genus *Erithizon* is recorded cave-deposits in Pennsylvania. *Atherura* is found in the cene of Southern India. *Hystrix* occurs in the Pleistocene iocene of India; in Europe from the Upper Pliocene of the Val down to the Middle Miocene, and perhaps to the Quercy horites; while in North America it is represented both in the ne and the White River Miocene. Finally, *Mylagaulus* from iocene of the United States may be allied either to *Hystrix* or *rocta* (Agouti).

ILY CASTOROIDIDÆ.—The gigantic *Castoroides*, of the Pleis- of the United States, is now generally regarded as entitled to ent a distinct family although originally placed in the *Cas-* . Although presenting certain cranial features recalling *Castor*, ntition comes nearest to that of *Chinchilla* and *Hydrochœrus.* xtinct genera *Loxomylus* and *Amblyrhiza*, from the Pleistocene Antilles, may probably be included in the same family; their on presenting many resemblances to that of *Chinchilla*. *Cas-s* must have attained the dimensions of a Bear.

ILY OCTODONTIDÆ.—With the exception of *Ctenodactylus* the er of the cheek-teeth in this Ethiopian and South American [1] is the same as in the *Hystricidæ;* these teeth having both ex- and internal enamel-folds, with either imperfect or perfect roots. South American Pleistocene we meet with existing and a few t species of the genus *Carterodon*, which is characterised by oad and grooved incisors, and also of *Myopotamus* (Coypu), *omys*, *Loncheres*, *Phyllomys*, and *Ctenomys*. Other forms from uth American Tertiaries allied to the latter have been named *amys* and *Pithanotomys;* while *Morenia* and *Orthomys*, from fra-Pampean beds of Parana, and *Tribodon*, from Monte Her- are regarded as related to *Myopotamus*. The extinct *Pelle-* , from the Sicilian Pleistocene, may be allied both to the oian *Ctenodactylus* and the American *Octodon.*

ILY THERIDOMYIDÆ.—This extinct family appears to be most related to the preceding although connected by *Archæomys* ne *Chinchillidæ*. The cheek-teeth number $Pm. \frac{1}{1}$, $M. \frac{3}{3}$. In

1 One species of *Echinomys* occurs in Central America.

Theridomys (fig. 1293, B) they are rooted, and have three or four re-entering enamel-folds, which form isolated disks on the worn crowns. This genus occurs in the Lower Miocene and Upper Eocene of Europe; while *Sylophodus* of the North American Miocene is closely allied. *Protechinomys* of the Lower Miocene and Upper Eocene of France has rooted cheek-teeth with crowns very like those of *Theridomys* and the living *Echinomys* (*Octodontidæ*); while *Archæomys* of the same deposits has the teeth devoid of roots, with their enamel-folds continuing across the crown, and dividing it into laminæ (fig. 1293, A). *Trechomys* is a fourth allied genus from the Quercy Phosphorites, having cheek-teeth somewhat like those of *Theridomys*, but with laterally-compressed crowns.

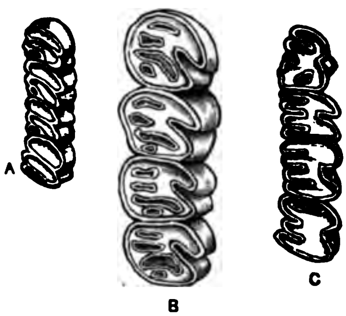


Fig. 1293.—A, Left lower cheek-teeth of *Archæomys*; B, Left upper cheek-teeth of *Theridomys*; C, Left lower cheek-teeth of *Chalicomys*. A and B enlarged. In B the uppermost, and in A and C the lowest, tooth is the premolar.

FAMILY DIPODIDÆ.—This and the four following families are embraced in the section Myomorpha. In the *Dipodidæ* (Jerboas) remains of the existing *Alactaga jaculus* occur in the Pleistocene of Europe, and those of *Zapus* (*Jaculus*) *hudsonianus* in the corresponding beds of North America; while a species of *Platycercomys* has been recorded from the Pleistocene of Northern Asia. The so-called *Dipöides* of the Tertiary of Würtemberg is probably a *Chalicomys*.

FAMILY GEOMYIDÆ.—The American Pouched-Rats, in which the cheek-teeth are *Pm.* $\frac{1}{1}$, *M.* $\frac{3}{3}$, are represented by species of the type genus *Geomys* in the Pleistocene and Pliocene of North America, and also by one existing species of *Thomomys* in the Pliocene of Oregon. In the Miocene of the United States two extinct genera are also met with, of which *Entoptychus* is allied to *Thomomys*, and has rootless molars and broad incisors; while *Pleurolichus* has rooted molars and the incisors without grooves, like those of the allied existing genus *Heteromys*.

FAMILY SPALACIDÆ.—This Old World family comprises burrowing Rodents, with large incisors, and rooted molars having re-entering enamel-folds. The only fossil representative is a *Rhizomys*, from the Siwalik Hills of India, which appears to be closely allied to the living forms; all of which are characterised by the absence of premolars.

FAMILY MURIDÆ.—The *Muridæ* form by far the largest family f the order, and are mainly characterised by certain peculiar features f the skull. With the exception of *Sminthus*, premolars are want-g; and the true molars, except in the Australian *Hydromys* and *eromys*, where they are reduced to $\frac{2}{2}$, are $\frac{3}{3}$ in number; while e lower incisors are laterally compressed. The molars may be oted or rootless, and either brachydont and tuberculate, or hypso-ont with re-entering enamel-folds. This family may be divided to several subfamilies. Of these the *Cricetinæ* have the cusps of e upper molars arranged in two longitudinal series; these teeth ing either rooted or rootless. This subfamily, which is now the ominant one in America, but was formerly largely developed in e Old World, where it is still found, appears to represent the chaic or generalised type of the family. In the Voles, or the ore specialised Cricetines, the cusps of the molars have become odified into triangular prisms alternately arranged (fig. 1294), and

Fig. 1294.—The left upper and lower molars of the Water-Vole (*Arvicola amphibius*). Enlarged.

he roots are generally not developed, so that the crowns are hypso-dont. *Siphneus*, which connects this family with the preceding, is ound at the present day in Central Asia, and is represented by a iving species in the Pleistocene of the Altai, and by another, which s extinct, in the Pliocene of Northern China. Of *Arvicola* (*Microtus*[1]), nd *Lemmus* (including *Cuniculus*), there are numerous species in he Pleistocene of Europe, some of which are identical with living orms, while others are extinct; the former genus being also repre-sented in the Forest-bed and the Coralline Crag. The allied *Fiber*, of North America, occurs also in the Pleistocene of the same country. In the typical or less specialised forms, the molars usually

[1] This name, as being earlier than *Arvicola*, is adopted by several recent writers.

have simple cusps, and are rooted. *Paciculus*, from the Miocene of the United States, is allied to the next genus, but has enamel-folds to the molars. *Neotoma* is represented by a species in the Pleistocene of the Pennsylvanian caves, which is perhaps not distinct from the living Florida-Rat. The genus *Cricetus*, typically represented by the European Hamsters, is taken by Mr O. Thomas to include the American *Hesperomys*. It is represented sparingly in the Pleistocene of Europe; but it is probable that *Cricetodon* (*Decticus*), which ranges from the Quercy Phosphorites to the Middle Miocene of France, cannot be generically separated. In America fossil forms occur abundantly in the Brazilian cave-deposits, where they have been described as *Hesperomys;* and it is probable that we must include in the same large genus (*Cricetus*) the so-called *Eumys* of the Miocene of North America. The subfamily *Deomyinæ* is only known by *Deomys*, of the Congo Valley, which has upper molars intermediate in structure between those of the preceding and following subfamilies. The *Murinæ*, or more specialised Mice, are mainly characteristic of the Old World, and do not date back far in time. Their upper molars have the cusps or tubercles arranged in three longitudinal rows and well-developed roots. *Mus*, or the closely allied *Acomys*, is first known from the Pliocene Pikermi beds, and thence is found through the Pleistocene of Europe. The Australian genera *Hapalotis* and *Mastacomys* are represented by existing species in the cave-deposits of that country. The Indian *Phlæomyinæ*, having broad upper incisors, and rooted molars with transverse laminæ, are represented in the Pleistocene of *Madras* by two species of *Nesocia* identical with those now inhabiting the same area. The *Gerbillinæ* also have laminated molars (fig. 1295), but the upper incisors are narrow and the hind limbs elongated. The existing *Gerbillus indicus* occurs fossil in the Madras caves. The last molar in both the upper and lower jaws of this genus has only a single transverse lamina, as shown in the figure. Lastly the *Sminthinæ*, in which there is a premolar in the upper jaw, are represented by the existing *Sminthus vagans* in the Pleistocene of Europe.

Fig. 1295.—The left ramus of the mandible, and the lower molars (enlarged) of *Gerbillus indicus;* from a cave in Madras.

FAMILY MYOXIDÆ.—In the Dormice the number of the cheek-teeth is *Pm.* $\frac{1}{1}$, *M.* $\frac{3}{3}$; these being rooted, with complex enamel-folds. For palæontological purposes all the forms may be included in *Myoxus*, which commences in the Paris gypsum and Quercy Phosphorites, and is represented in the Pleistocene of Malta by a species of the size of the Guinea-pig. The so-called *Brachymys* of the German Miocene appears to be generically the same.

As Myomorpha, of which the affinities are uncertain, may be mentioned *Heliscomys*, of the North American Miocene, in which there are four lower cheek-teeth, and the lower incisors are compressed and grooved; and *Eomys* (or *Omegodon*), from the Quercy Phosphorites, in which the cheek-teeth are *Pm.* $\frac{1}{1}$, *M.* $\frac{3}{3}$. *Colonomys*, from the North American Miocene, also belongs to this section.

FAMILY CASTORIDÆ.—With this family we enter the Sciuro-

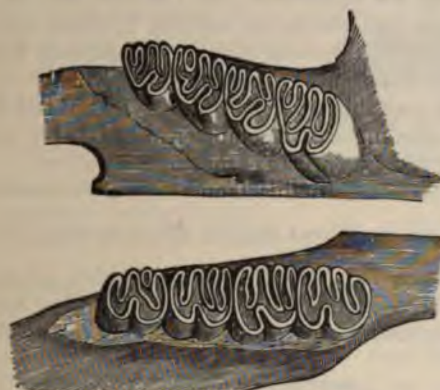


Fig. 1296.—Palatal aspect of the right upper and lower cheek-teeth of the Beaver (*Castor fiber*). The tooth on the right of each figure is the premolar.

morpha, which includes all the remaining Rodents. The Beavers are natatorial Rodents, with *Pm.* $\frac{1}{1}$, *M.* $\frac{3}{3}$; the cheek-teeth being semi-rooted or rootless, with re-entering enamel-folds (fig. 1296). *Castor* is represented by the existing Beaver in the European Pleistocene, and by an allied form in the Pliocene of the Auvergne; and also occurs in the Miocene of North America, where it has been named *Eucastor*. There has been great dispute as to the affinities of the great extinct Beaver (fig. 1297) of the Norfolk Forest-bed and Norwich Crag, but it is regarded by Mr Newton as identical with both *Trogontherium* of the Russian, and *Diobroticus* of the French Pleisto-

Fig. 1297.—Right ramus of the mandible of *Trogontherium Cuvieri*; from the Forest-bed. One-fourth natural size. (After Owen.)

cene. An allied genus is *Chalicomys* (*Steneofiber*), in whic humerus has a foramen, and the molars (fig. 1293, c) are mo tinctly rooted, with shallower enamel-folds; it occurs in Eur the Middle and Lower Miocene, and also in the Miocene of America; *Palæocastor* from the latter deposits being app closely allied.

FAMILY ISCHYROMYIDÆ.—*Ischyromys* (with which *Tillo* apparently identical) is a North American Miocene genu $Pm. \frac{2}{1}, M. \frac{3}{3}$; having dental characters of the *Sciuridæ*, but wise resembling the *Hystricidæ* and *Caviidæ*, and thus inc that the sections into which the existing Rodents are divic not hold good for all the fossil forms. *Pseudotomus* from the River Miocene is an allied form; while *Sciuromys* of the Phosphorites is probably also related. *Mysops* of the North can Eocene, according to Dr Schlosser, may be the same as *romys*. *Gymnoptychus* (p. 1421) may also be allied.

FAMILY SCIURIDÆ.—In this family the cheek-teeth are $Pm. \frac{2}{1}, M. \frac{3}{3}$, but in *Sciurus* the first upper premolar is often The molars are rooted, and, with the exception of *Eupetau* Kashmir, are brachydont; those of the upper jaw usually triangular or squared crowns, with two or more shallow inf

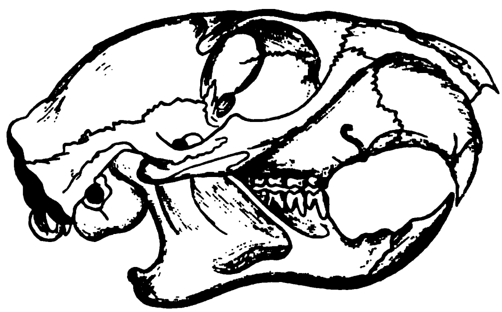


Fig. 1298.—Side view of the skull of *Cynomys Ludovicianus*.

enamel from the outer side (fig. 1299). The Marmots an allies (fig. 1298) have uncompressed incisors; and the type *Arctomys* is represented by the existing *A. marmotta* (fig. 1: the Pleistocene of Europe, and by another species in t North America. *Plesiarctomys* (with which *Sciuravus*, Mar *Paramys*, Leidy, are identical) occurs in the Middle Tertia both Europe and the United States, and connects *Arctom* *Sciurus*. *Spermophilus*, or the Sousliks, has both living and ecies in the Pleistocene of Europe; while the allied *Plesisper-ophilus* has been described from the Quercy Phosphorites. mong the Squirrels, of which the living genera have compressed cisors, *Sciurus* itself ranges down to the Quercy Phosphorites in urope, and in North America occurs in the White River Mio-ne; the common existing *S. vul-ris* being found in the Norfolk rest-bed. The recent northern nus *Tamias* occurs in the Pleis-cene of Europe and Nebraska; ile *Pseudosciurus* and *Sciuroides* e allied extinct genera from the pper Eocene of the Continent, in th of which the molars are more ongated than in *Sciurus*. *Gym-ptychus*, with *Pm.* $\frac{1}{1}$, *M.* $\frac{3}{3}$, from e Miocene of North America, as more complex molars, and ereby approaches *Pteromys*; while *Meniscomys* (with which *Allo-ys* is apparently identical), with *Pm.* $\frac{2}{1}$, from the same deposits, resents some resemblances to the American *Haplodontidæ* (which, ke the *Anomaluridæ*, are unknown in a fossil state), *Sciurodon* rom the Quercy Phosphorites is regarded as a closely allied enus.

Fig. 1299.—Palatal view of the right upper and lower dentition of the Marmot (*Arctomys marmotta*). Recent and Pleistocene, Europe. The two teeth on the right side of the upper figure are the premolars.

Finally, we may here mention the small *Decticadapis*, of the Lower Eocene of Rheims, which appears to be a Rodent, although its affinities cannot yet be determined.

Order VIII. Carnivora.—Although the existing Carnivora can be defined with fair exactness, yet the fossil forms here included in this order render such definition almost or quite impossible. All the known forms are, however, unguiculate, with never less than four digits to each foot, all of which bear claws; and the pollex and hallux are never opposable. The dentition is diphyodont and heterodont, and (with the exception of the canines of the *Trichechidæ*) the teeth have closed pulp-cavities. The incisors are very generally three in number, the third being the largest; the canines are strong, pointed, recurved, and larger than the incisors; while the first pair of incisors never have an interval between them. The cheek-teeth vary, but are usually compressed in the anterior part of the series; while if the molars are tuberculate, they are not complex and divided into lobes by deep infolds of enamel. The condyle of the mandible forms a transversely elongated half-cylinder, working in a deep glenoid fossa, protected by a large postglenoid process. The clavicle is never complete, and is frequently absent; the radius and ulna and the tibia and fibula are always distinct; but the scaphoid and lunar of the carpus very frequently coalesce. In a large number of cases the humerus has an entepicondylar foramen. The majority of the species subsist on animal food. In the more specialised types there is a tendency to a reduction in the number of the cheek-teeth, more especially the true molars.

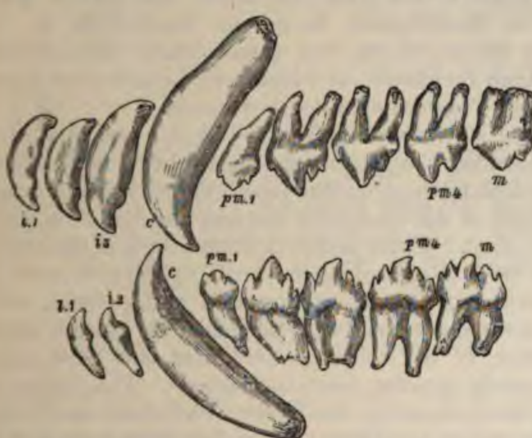
As in the Rodents and the following orders, the manus is susceptible in most cases of the movements of pronation and supination; the head of the radius being accordingly freely movable in the lesser sigmoid cavity of the ulna. The proximal extremity of the latter bone is shown in the accompanying woodcut in order to exhibit the characteristic features obtaining in the unguiculate orders. Some observations on the phylogeny of the order will be found under the head of the Creodonta.

Fig. 1300.—Anterior aspect of the proximal extremity of the right ulna of *Hyænarctus*; from the Siwalik Hills. Reduced. *ol*, Olecranon; *a*, Anterior tubercle of do.; *sig*, Sigmoid cavity; *l.sig*, Lesser do. for head of radius.

The Carnivora are divisible into the suborders Pinnipedia, Carnivora Vera, and Creodonta; the latter being the most generalised.

SUBORDER I. PINNIPEDIA.—This suborder comprises the typical Seals (*Phocidæ*), the Walruses (*Trichechidæ*), and the Eared, or Fur, Seals (*Otariidæ*); all of which mainly differ from the typical Carnivora in points connected with their subaquatic life. The brain is relatively large, with its hemispheres much convoluted, and broad in proportion to their length. The limbs are short, and are each furnished with five digits, which are connected by a web: in the hind feet the first and fifth digits are stouter, and generally longer, than either of the others. In the *Phocidæ* the hind feet when walking are directed backwards parallel to the axis of the body, but in the *Otariidæ*, which are the least aberrant members of the suborder, they are turned forwards. The dentition varies, but at least three kinds of teeth are always present. The canines are long and pointed; the cheek-teeth (fig. 1301), which usually comprise four premolars and one true molar, are not differentiated into carnassials and tuberculars, but are usually sharply pointed and often furnished with fore-and-aft basal cusps, although they are blunt and rounded in the Walrus. There is always a diminution of the incisors below pical number of $\frac{3}{3}$. The milk-teeth are very minute, and are shed or absorbed at a very early date. The structure of the m approximates to that of the Bears and their allies. The limb-bones present very characteristic features, which enable to be readily recognised in the fossil state. No fossil forms een hitherto found which tend to throw any light upon the of this suborder; but in the reduction of the number of the s, they agree with some of the Creodonts, from which group ay be directly derived.

ILY PHOCIDÆ.—The number of incisors in this family varies in *Cystophora* to $\frac{3}{2}$ in *Phoca* and *Halichœrus*. The best fossil Seals have been obtained from the Pliocene Crag of rp, and have been referred to the following genera, of which



301.—Lateral view of the left dentition of *Phoca*. Reduced. Letters as in fig. 1302.

t the first are peculiar to the Tertiary, although it may be tion whether all of them are rightly distinguished from exist-nera. They comprise *Phoca*, represented by a species allied Common Seal (*P. vitulinoides*); *Callophoca* allied to the land Seal (*P. grœnlandica*); *Platyphoca* to the Bearded Seal *rbata*); *Phocanella* to the Ringed Seal (*P. fœtida*); *Gryphoca* Grey Seal (*Halichœrus*); *Palæophoca* and *Monatherium* to onk Seal (*Monachus*) of the Mediterranean; *Mesotaria* to the er Seal (*Cystophora*); and *Prophoca* which does not appear allied to any existing form. Remains of *Phocidæ* in other ions are rare; but a species provisionally referred to the type

spects intermediate between the other two familie
tinguished by their enormous upper canines. Th
Trichechus rosmarus occurs fossil in the Norfolk F
allied species, *T. Huxleyi*, in the Red Crag; while
therium and *Trichechodon* have been applied to cl
generically identical, forms from the Belgian Crag.

FAMILY OTARIIDÆ.—This family, in which th
incisors is invariably $\frac{3}{2}$, is almost unknown i
although some writers have considered that cer
included in the *Phocidæ* should be referred
of existing species of the type genus *Otaria* hav
obtained from Prehistoric or Pleistocene beds in I
also from the Pleistocene of South America.

SUBORDER 2. CARNIVORA VERA.—In the typic
brain is relatively large, and the hemispheres a
always marked by three or four folds. The fore
the first digit, or the hind limbs the first and the
than all the rest. There is always a more or less
carnassial tooth in each jaw; the teeth in front
being always more or less compressed and poi
behind the same are broad and tuberculated. Ar
the dentition of the suborder Creodonta that t
posterior teeth are the most specialised. The
(p^4, fig. 1302), as being the hindmost of those
milk predecessors, is reckoned as the last premola
consists of an outer compressed blade, generally f
(fig. 1302), but occasionally (fig. 1325) with thre
and of an inner tubercle (fig. 1325). This tub
placed near the anterior extremity of the crown, a
size; but in some instances, as in *Machærodus* (
be almost absent while in others as in the Ott

fig. 1331), both the inner cusp of the blade and the talon may be entirely wanting; or, again, the talon, as in *Ursus* (fig. 1309), may attain excessive development, and the blade be proportionately reduced; the cusps or lobes of the latter being in such cases placed obliquely.

Although the foregoing terms are those generally used in describing the carnassial teeth, a few words may be said as to the serial homology of their cusps. Thus, in the normal type of upper carnassial with two

Fig. 1302.—Outer lateral view of the left dentition of the Wolf (*Canis lupus*). Reduced. *i*, Incisors; *c*, Canine; *p*, Premolars; *m*, True molars.

lobes to the blade (fig. 1318, *pm.* 4), it appears that the inner tubercle represents the protocone of the tritubercular type (p. 1275), the first lobe of the blade corresponding to the paracone, and the second to the metacone. In those forms with a trilobed blade (fig. 1325), the anterior lobe is a superadded element not found in the primitive type. In the lower carnassial (compare fig. 1145, p. 1275) the posterior lobe of the blade, which is really external, is the protoconid; the anterior lobe (paraconid) and the inner cusp (metaconid) are both internal; while the talon is the hypoconid.

With very few exceptions, the incisors are $\frac{3}{3}$ in number. The digits are nearly always furnished with long, sharp, and more or less curved claws, which in the true Cats (*Felis*) can be retracted into protecting bony sheaths. In some genera, like *Ursus*, the whole of the sole of the foot is applied to the ground in walking (*plantigrade*), while in others, like *Canis*, only the terminal digits are so used (*digitigrade*). As a feature of some importance in this suborder, mention must be made of the *alisphenoid canal*, which is a short bony channel situated in the alisphenoid bone immediately on the outer side of the pterygoid. The existing representatives of this suborder have been divided into three sections—the Arctoidea, Cynoidea, and Æluroidea; but extinct forms show such a complete transition between the three that it is impossible to adopt any divisions of higher rank than families, and scarcely any two writers agree as to the limits of the latter. It is, moreover, very doubtful whether the Arctoidea is really a natural group. When, indeed, we go back to the Upper Eocene or Lower Oligocene, where this suborder is first definitely known, we find that Bears pass imperceptibly into Dogs, Dogs into Civets, Civets into Hyænas and Cats, while Weasels appear to be related to the Civets; and the principles adopted in the classification of recent forms consequently fail to enable us to make any really satisfactory arrangement.

FAMILY MUSTELIDÆ.—This family comprises the Sea-Otters, Otters, Badgers, and Weasels. In all existing forms the skull has no alisphenoid canal; there is never more than one upper true molar, and the lower true molars are nearly always two, although reduced to one in *Mellivora*. The upper true molar has its inner tubercular portion wider than the outer or cutting moiety (fig. 1306), this feature being most developed in the Otters (fig. 1303); and the

Fig. 1303.—Palate of *Lutra cinerea*; India.

cusps of the blade of the lower carnassial are comparatively low (fig. 1308). The palate is comparatively wide, and the premolars are somewhat crowded together; while the auditory bulla has no septum, and is usually, but slightly, inflated. It is suggested by Dr Scott that the *Mustelidæ* are a branch from the primitive *Viverridæ*, and there is considerable evidence in favour of this view, which, if true, at once breaks up the Arctoidea.

The existing *Lutrine* section may be palæontologically divided into *Lutra* and *Enhydra*; the latter being a marine form unknown n a fossil state. The species of *Lutra* are characterised by the reat constriction of the skull in the orbital region, and usually by he more or less squared contour of the crown of the upper true nolar, and the great development of the inner tubercle of the last pper premolar, which forms a crescentoid ridge; both these features eing well shown in fig. 1303. In the typical *L. vulgaris* the dental ormula is $I.\ \frac{3}{3},\ C.\ \frac{1}{1},\ Pm.\ \frac{4}{3},\ M.\ \frac{1}{2}$, but in some existing species the rst upper premolar may be absent (fig. 1303), and other variations ccur in fossil forms. This genus may be divided into three groups, which it is quite permissible to regard as distinct genera, and of which the first and third are extinct. The *Enhydriodont*, or most pecialised group, comprises two large otters respectively from the Pliocene Siwaliks of India and the Middle Miocene of Italy, which ttained dimensions fully equal to those of the existing *L. brasiliensis*. In both these forms the first upper premolar is absent, and in the Indian *L. sivalensis* the second premolar may likewise disappear. In this species, moreover, the fourth upper premolar or carnassial (fig. 1305) differs from that of all other otters in that the inner crescent consists of three distinct tubercles; but the Italian *L. Campanii* (fig. 1304) connects in this respect the Indian species with the true otters. The typical group, which includes all the existing forms, is known to date from the Middle Miocene of Europe, and also occurs in the Tertiaries of America and the Indian Siwaliks. Remains of the existing *L. vulgaris* occur in the Norfolk Forest-bed; while the Siwalik *L. palæindica* is closely allied in the structure of its teeth and skull to the living hairy-nosed otter (*L. sumatrana*) of Asia. Finally, the *Lutrictine* group is represented only by *L. Valetoni*, of the Lower Miocene of the Continent, which is distinguished from all other Mustelines by the presence of a minute second upper true molar. This species is also characterised by the narrowness of the first upper true molar, and by the circumstance that the anterior upper premolars are placed immediately behind the canine, instead of being squeezed towards its inner side, as in fig. 1303. If regarded as generically distinct, this form should be known as *Potamotherium*. The Miocene *Trochictis* appears to connect the Otters with the Weasels.

Fig 1304.—The right upper carnassial of *Lutra Campanii*; from the Miocene of Italy. In its natural position the outer ridge would be oblique, as in fig. 1303.

Fig. 1305.—The left upper carnassial of *Lutra sivalensis*; from the Pliocene of India. The outer ridge is broken.

Among the Badgers and their allies extinct species of the type genus *Meles* occur in the Pliocene of Persia, the common Bad (*M. taxus*) being found in the Pleistocene of Europe; while ext species of *Mellivora*, or Ratel (fig. 1306), have been described f the Pliocene of India, this genus being confined to that cou

Fig. 1306.—The right upper and left lower dentition of *Mellivora sivalensis*; from the Pliocene of India.

and Africa. The last-named deposits also yield the extinct *vorodon*. Species of the American genus *Mephitis* (*Con* occur in the Pleistocene cave-deposits of Brazil; while *Prom* of the Pliocene of Greece, is considered to be allied. *Palæom* of the Miocene of Bavaria, which has been placed in this appears to be identical with *Viverra*.

The Weasels, or typical representatives of the family, wh divided into the existing genera *Mustela* (including *Putorius*) and *Galictis*, occur commonly throughout the higher Te

Mustela (fig. 1307), in which the premolars vary from $\frac{3}{3}$ to the inner cusp of the lower carnassial is frequently absent, i sented by numerous existing species in the Pleistocene of I and by a number of extinct forms, some of which it has be posed to separate under the names of *Plesiogale* and *Palæogal* ing down to the Quercy Phosphorites. A large species (fig. occurs in the Siwaliks of India, which was probably closel to *M. flavigula* of the same regions; and other large for in the Miocene of Bavaria, and the Pliocene of Greece and ; while the genus is also represented by a smaller species in 'liocene of North America. *M. Larteti* of the Miocene of n should perhaps be referred to the African genus *Ictonyx*.

Fig. 1307.—Right lateral view of the skull of the Polecat (*Mustela putorius*).

extinct *Plesictis* occurs in the Lower Miocene and Upper ne (Oligocene) of Europe, and is characterised by the presence premolars, and the circumstance that the temporal ridges of ranium do not unite to form a sagittal crest, as they do in *ela*. The inner portion of the upper true molar, as in some e Miocene species of *Mustela* (*Palæogale*), be- s narrower than the outer, and the auditory is more inflated; both these features indicat- ffinity with the Viverrine genus *Stenoplesictis*. existing genus *Galictis* of America is repre- d in the Pleistocene of the two divisions of Continent; while the Arctic *Gulo* occurs in the ocene of Europe, where remains of the existing erine (*G. luscus*) are met with.

Fig. 1308.—Upper and outer view of the left lower carnassial of *Mustela*; from the Pliocene of India.

MILY PROCYONIDÆ.—The *Procyonidæ* may be to include both the American Racoons and s and the Indian *Ælurus*, but are of small ntological importance. In all living genera the true molars in number; and the American forms have no alisphenoid . *Nasua* (Coati) occurs fossil in the Pleistocene of Brazil; the extinct *Cynonasua*, characterised by the presence of three true molars, is found in the older *infra*-Pampean of Pata- . *Procyon* (Racoon) is represented in the Pleistocene of America; while *Leptarctus* from the same deposits, and *dus* from the Pleistocene of South Carolina, are extinct genera connecting the present family with the next. *Ælurus* is repre at the present day by a single species from Nipal and the ad regions. In common with the American members of the fa is characterised by the second lower true molar being longe the first, and by the absence of a "carnassial" character latter. The molars are, however, of an unusually complex cha and the last one of the lower jaw presents a decided approxi to the third molar of certain Ungulates. The only fossil th been referred to this genus is a fragment of a mandible with t true molar from the Red Crag of Suffolk. It is, however, ad to await further information before admitting this determina certain.

FAMILY URSIDÆ.—Palæontologically it appears advisable clude in this family not only the Bears, but also the Dogs (*C* since the passage from one type to the other is so complet render it impossible to draw any satisfactory distinction b them. Although no precise definition of this family can be the following points may be noticed. With the exception

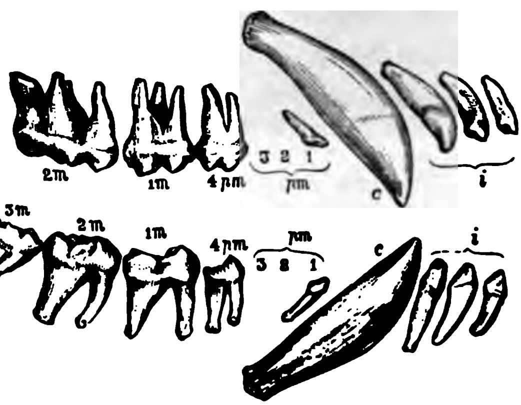


Fig. 1309.—Outer view of the right dentition of the Polar Bear (*Ursus maritim* Reduced. *i*, Incisors; *c*, Canine; *pm*, Premolars; *m*, True molars.

existing genus *Æluropus* the skull has an alisphenoid canal. upper true molars are frequently two in number, but they r reduced to one (*Icticyon*), or increased to three (*Amphicyon*) ((*Otocyon*); while the corresponding teeth of the lower jaw are always three in number, although they may be reduced to tw in *Otocyon* are augmented to four. The first upper true m invariably placed behind the carnassial, and the latter genera two lobes. The upper true molars may have either oblong (squared (*Hyænarctus*), or triangular crowns; and the talon lower carnassial is well developed. The auditory region may either have a depressed bulla, without an inner septum (*Ursus*), as in the existing *Mustelidæ*, or (*Canis*) may have an inflated bulla with an incomplete septum approximating to that of the *Viverridæ*. The least

Fig. 1310.—Right lateral aspect of the skull of the Cave-Bear (*Ursus spelæus*); from the Pleistocene of Germany. Reduced.

specialised forms have an entepicondylar foramen to the humerus, and a third trochanter to the femur. The feet are digitigrade in *Canis* and plantigrade in *Ursus*. In common with the majority of the Carnivora Vera, and also many of the Creodonta, the second lower incisor is thrust up above the line of the first and third.

In the type genus *Ursus* the dental formula is usually $I. \frac{3}{3}, C. \frac{1}{1}, Pm. \frac{4}{4}, M. \frac{2}{3}$, but in *U.* (*Melursus*) *labiatus* the number of the incisors is reduced to $\frac{2}{3}$. The second and third premolars are usually shed at an early age; the upper carnassial (*pm.* 4, fig. 1309) is shorter than the first true molar, and lacks the marked sectorial character which it presents in most other Carnivora; and the upper true molars are greatly elongated, and have flat tuberculated crowns. The foramen has disappeared from the humerus; and the olecranon of the ulna (fig. 1311) has become very short; while the femur has no third trochanter. This genus may be regarded as in some respects very specialised, although retaining generalised features in its plantigrade and pentedactylate feet. It is of com-

Fig. 1311.—Anterior aspect of the proximal extremity of the right ulna of *Ursus arctus*. One-half natural size. Letters as in fig. 1300.

paratively modern origin; the earliest known species being *U. Theobaldi*, of the Pliocene of India, which was the ancestor of the existing *U. labiatus* of the same country. The last-named species is found in a fossil state in the caves of Madras. In the Upper Pliocene of Europe we have the small *U. etruscus*; and in the Pleistocene of the same area the existing European Brown Bear (*U. arctus*), the allied or identical North American Grizzly (*U. horribilis*), and the huge extinct *U. spelæus*, or Cave-Bear (fig. 1310). The latter species is characterised by the prominent ridge above the orbits, and the extremely fine tuberculation of its molars; its remains are found in extraordinary abundance in the bone-caves

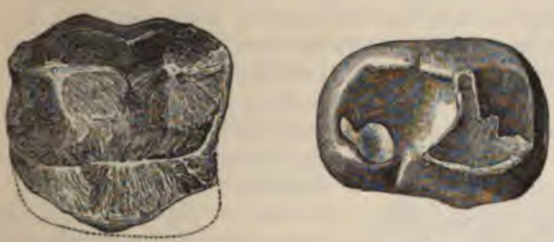
Fig. 1312.—Palate of *Arctotherium bonariense*; from the Pleistocene of South America. One-fourth natural size.

of the Continent. Very noteworthy is the occurrence of abundant remains of Bears in the caverns of North Africa, since but one living species is found in the whole of that vast continent. In the Pleistocene of South America and California we meet with the huge *Arctotherium* (fig. 1312), in which the upper carnassial is relatively longer than in *Ursus*, while the crowns of the true molars are more nearly square; so that its dentition serves to connect that of *Ursus* with that of the next genus. According to Professor Cope the humerus has a foramen. The genus *Hyænarctus* occurs first in the Middle Miocene of Europe, where the species are of small size

g. 1313), and is represented by much larger forms in the Pliocene India, China, and Europe. In this genus the proximal extremity the ulna (fig. 1300) has an elongated olecranon similar to that *Amphicyon* and *Canis*. There is also a third lobe to the upper rnassial (whereby it resembles the corresponding tooth of *Hyæna*), hile the first upper true molar is square g. 1314) in one species, and imperfectly iangular in another; the lower carnassial sembling that of *Canis*. The small *H. tthracitis* of the Middle Miocene of Italy ay be identical with *H. minutus*. Before oticing the forms connecting *Hyænarctus* ith *Canis*, we must mention some extinct enera more or less nearly allied to the esent group, and which Dr Schlosser so regards as related to the *Procyonidæ*. mong these are *Simocyon* (*Pseudocyon* or *Ietarctus*) of the Pliocene of Greece and Iungary, in which the number of the heek-teeth is *Pm.* $\frac{2}{(2-4)}$, *M.* $\frac{2}{2}$; and *Enydrocyon* (fig. 1315), of the Miocene of Iorth America, in which the cheek-teeth

Fig. 1313.—Outer and palatal aspects of the left upper true molars of *Hyænarctus minutus*; from the Middle Miocene of Silesia. (After Koken.)

umber *Pm.* $\frac{3}{3}$, *M.* $\frac{2}{2}$, the cranium is very short, and the lower arnassial has a cutting talon. *Oligobunis* of the Miocene, and *Tomarctus* of the Pliocene of the same country are also more or



A B

Fig. 1314.—First upper (A) and second lower right true molar (B) of *Hyænarctus*; from the Pliocene.

ess nearly related types. Here we may also place *Hyænocyon* of he Miocene and *Ælurodon* (*Prohyæna*) of the Pliocene of North America, though Dr Schlosser, on wholly insufficient grounds, would refer both to the *Hyænidæ*. The former has the molars reduced to $\frac{1}{1}$; while in the latter the upper carnassial has three lobes like *Hyænarctus*, the number of teeth according to Professor Cope being the same as in *Canis*, and the humerus having no foramen. More nearly allied to the *Hyænarctus* group is *Cephalogale*,

Fig. 1315.—Lateral and upper view of one-half of the cranium of *Enhydrocyon stenocephalus*; from the Miocene of North America. One-half natural size. (After Cope.)

in which the two upper true molars (fig. 1316) become more or less triangular, but the carnassial in both jaws (figs. 1316, 1317) is comparatively short, with low cusps. This genus, according to Dr Schlosser's emendation, is comparatively abundant in the Upper Eocene and Lower Miocene of the Continent; many of the species having been included by Dr Filhol in *Cynodictis*. Extremely near to those species of *Hyænarctus* in which the upper true molars are triangular is the gigantic *Dinocyon* from the Middle Miocene of Europe, in which the above-mentioned teeth become perfectly triangular like those of *Canis*; and we may here mention *Brachycyon* from the Upper Eocene of France. The widely-spread genus *Amphicyon* (in which *Pseudamphicyon* of Dr Schlosser may be in part included) occurs in Europe from the Upper Eocene to the

Fig. 1316.—The last four left upper teeth of *Cephalogale Gryei*; from the Upper Eocene of France.

Middle Miocene of Europe, and is also found in the Pliocene of India; the forms from the Upper Eocene of North America which have been referred to it, are regarded by Dr Scott as distinct, and have been named *Daphænus*. Its teeth closely resemble those of *Canis*, but there are three upper true molars; the femur has, however, a third trochanter, the feet are plantigrade and pentedactylate, the distal end of the humerus has a foramen, and the auditory bulla is somewhat inflated, with either a very rudimentary or no septum.[1] This genus has therefore the dentition of a Dog, coupled with limbs more like those of a Bear; and it is a curious comment on the attempt to maintain the families *Canidæ* and *Ursidæ* that while Professor Flower places *Amphicyon* in the former, Dr Schlosser refers it to the latter. This genus is evidently a very

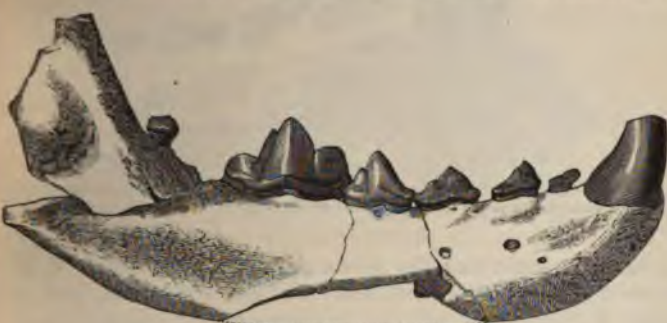


Fig. 1317.—Right ramus of the mandible of *Cephalogale brevirostris*; from the Upper Eocene of France.

generalised form, from which many others may have been derived. In *Canis*, comprising the Dogs, Wolves, and Foxes, the dental formula is normally $I.\ \frac{3}{3},\ C.\ \frac{1}{1},\ Pm.\ \frac{4}{4},\ M.\ \frac{2}{3}$, but in some forms (*Cyon*) the lower true molars may be reduced to two, and in others (*Lycorus*) there are but three lower premolars, while occasionally the third upper true molar is retained. The characteristic features of the teeth are shown in figs. 1302 and 1318; but it may be observed that the relative length of the carnassial and the degree of obliquity of the cusp-line in the lower carnassial varies in different species; the most specialised forms showing the greatest development of these features. The third lower premolar has a hinder basal cusp which is usually wanting in *Amphicyon*; the humerus has no foramen; the femur has lost the third trochanter; the feet are digiti-

[1] The general characters of the base of the skull of *Amphicyon* are Canoid, but in the presence of postparietal and mastoid foramina it agrees with the Bears.

grade; and the hallux is wanting in the pes. This genus probably commenced in the Upper Miocene of Œningen, and is widely distributed over all the world from the Pliocene upwards. The Wolf (*C. lupus*) ranges down to the European Pleistocene, and the allied *C. Cautleyi* is found in the Pliocene of the Siwalik Hills. *C. curvi-*

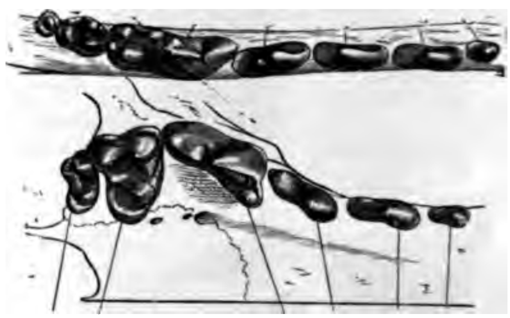


Fig. 1318.—Palatal aspect of right lower and upper dentition of *Canis argentatus*. The oblique line in the lower carnassial is the cusp-line. (After Huxley.)

palatus of the latter deposits shows signs of affinity with the African *Otocyon* (Fennec). *Lycaon*, now confined to Africa, and distinguished by having an anterior cusp to the last lower premolar, is found in the Pleistocene of Glamorganshire. *Palæocyon*, of the Brazilian Pleistocene, is regarded by Dr Schlosser as indistinguishable from *Canis*. *Temnocyon*, of the North American Miocene, has the talon of the lower carnassial secant, and a foramen to the hume-

Fig. 1319.—Left ramus of the mandible of *Cynodictis lacustris*; from the Upper Eocene of France. (After Gaudry.)

rus; while in the existing American *Icticyon* (*Speothos*), which is represented in the Brazilian Pleistocene, the lower carnassial has not only a secant talon but also lacks the inner cusp. Perhaps, however, the most interesting genus of the whole group is *Cynodictis* (in which we may include *Cynodon*, *Amphicynodon*, and *Pachycyno-*

don), of the Upper Eocene and Lower Miocene of the Continent, and also of the White-river Miocene of North America, where it has been described as *Galecynus*. In this genus the dental formula is usually the same as in *Canis*, but in some cases (as in that genus) there are only two lower true molars. The teeth (figs. 1319, 1320) resemble also those of the *Viverridæ*, the carnassials being never very long, and the cusp-line of the lower one transverse; and the humerus has a foramen. The auditory bulla is inflated, but according to Dr Filhol, has no septum. This genus is, indeed,

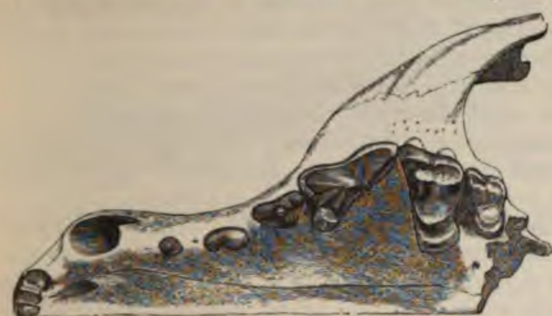


Fig. 1320.—Left half of the palate of *Cynodictis longirostris*; from the Upper Eocene of France.

one closely connecting the Canoids and Viverroids; and since it is pretty evident that the *Hyænidæ* and *Felidæ* are divergent branches from an early Viverroid stock it is probable that *Cynodictis* represents a type not far removed from the one which has given rise to several of the more specialised Carnivores, and is itself derived from *Amphicyon*, or an allied type.

Family Miacidæ.—This family is provisionally adopted to include the Eocene genera *Miacis* and *Didymictis*, which appear to be primitive forms allied to both Canoids and Viverroids, but which Professor Cope placed among the Creodonta. *Miacis* (= *Uintacyon* and *Viverravus*) occurs in the Upper, or Bridger, Eocene of North America, and according to Dr Schlosser, who places it with the Canoids, in both the Lower and Upper Eocene of France. *Didymictis* (*Limnocyon*), which occurs in the Puerco, Wasatch, and Bridger Eocenes of North America, is included by Dr Schlosser in the *Viverridæ*. *Dromocyon* is noticed on page 1453.

Family Viverridæ.—The Viverroids are comparatively small Carnivores, showing such close affinities in one direction with *Cynodictis* among the *Ursidæ*, in another with the *Mustelidæ*, and in a third with the *Hyænidæ* and the *Felidæ*, that their accurate definition is quite impossible. The skull in existing forms generally has an alisphenoid canal; and the auditory bulla is inflated and has a complete septum. There are usually two true molars in each jaw, although the second is wanting in *Prionodon*. Those of the upper jaw (fig. 1322) are usually triangular, and are always narrower internally than externally, although they may be narrow in *Viverra* (fig. 1322) and very broad in *Paradoxurus*; and, except in *Cryptoprocta* are placed behind the carnassial. The cusps of the lower carnassial are generally very tall; the premolars are spaced; and the palate, like the entire skull, is long and narrow. The upper carnassial is subject to great variation in relative length. In typical forms the blade of the lower carnassial has an inner cusp, while its cusp-line is transverse, and the talon is relatively large. The humerus usually has an entepicondylar foramen. The feet are plantigrade, and usually have five complete digits; and their claws, as a rule, are comparatively straight and only slightly retractile, and are not protected by a bony sheath. Exclusive of *Miacis* and its allies, which are here regarded as representing a separate family, the *Viverridæ* are characteristic of the Old World. The Oriental genus *Paradoxurus*, characterised by its broad upper molars, is at present unknown in a fossil condition. The more widely spread *Herpestes* (Mongoose) is characterised by its narrow upper molars, by the presence of an inner tubercle to the third upper premolar, and of a hinder cusp to the fourth lower premolar. This genus is represented in a fossil state by remains of the existing *H. nipalensis* (fig. 1321) in the Pleistocene of India, and by extinct species in the Upper Eocene and Miocene of Europe. *Amphictis*, from the Lower Miocene (Upper Oligocene) of France, seems to be closely allied to *Viverra*, but the second lower true molar is longer and has two distinct roots. The type genus *Viverra* (fig. 1322), which has no inner tubercle to the third upper premolar, commences in the Upper Eocene of England and France (*V. Hastingsiæ* and *V. angustidens*), and occurs right through the succeeding Tertiaries till the Lower Pliocene of France, where it is represented by *V. Pepraxti*. The latter Civet, together with other allied species from the Pleistocene and Pliocene of India, presents, however, certain dental features in which it approximates to *Ictitherium*. The Oriental genus *Prionodon*, in which there is only one upper true molar, and the inner cusp of the lower carnassial is very small, while the humerus has a foramen, is not known to occur in a fossil state. So far as can be determined from the lower

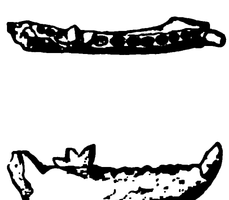


Fig. 1321.—The right ramus of the mandible of *Herpestes nipalensis*; from the Pleistocene of Madras. All the teeth except the carnassial and the canine are wanting.

w, *Palæoprionodon*, of the Quercy Phosphorites, appears to be so osely allied to *Prionodon*, that it is somewhat difficult to see how can be even generically separated. Closely allied to *Palæoprion-don* is *Stenoplesictis*, from the same deposits, in which the dental rmula is $I. \frac{3}{3}, C. \frac{1}{1}, Pm. \frac{4}{4}, M. \frac{2}{2}$, or the same as in *Viverra*. his genus presents, however, decided indications of affinity with

Fig. 1322.—Palatal aspect of the left upper dentition of the Zibeth (*Viverra zibetha*); from India.

he Musteloid *Plesictis*, on which account it is placed by Dr chlosser, together with *Palæoprionodon*, in the same family; but s dentition and the contour of the skull are decidedly Viverrine, nd, according to Dr Scott, the bulla has a complete septum, of which the position is visible externally, as in modern Viverrines. t is, however, quite probable that we may have in these generalised

Fig. 1323.—Palatal aspect of the left upper dentition of *Ictitherium robustum*; from the Pliocene of Greece. (After Gaudry.)

rms the ancestral types of the *Mustelidæ*, which from this view ill have lost the septum of the bulla independently of the Bears. n all the above-mentioned genera the upper carnassial has only two bes, but in *Ictitherium* (*Thalassictis*) they are increased to three, s in *Hyæna*. *Ictitherium* occurs in the Lower Pliocene of Greece, Iungary, and France; and its upper true molars (fig. 1323) have become relatively smaller than in *Viverra*, and in the figured species have a tendency to become placed on the inner side of the carnassial. The genus *Cryptoprocta*, which is unknown in a fossil state, approximates in the character of its dentition and its semi-retractile claws to the *Felidæ*.

FAMILY HYÆNIDÆ.—The above-mentioned genus *Ictitherium* may without much doubt be regarded as the ancestral type of the *Hyænidæ*, which form a family of comparatively recent origin and entirely confined to the Old World.[1] The transition to *Ictitherium* is indeed

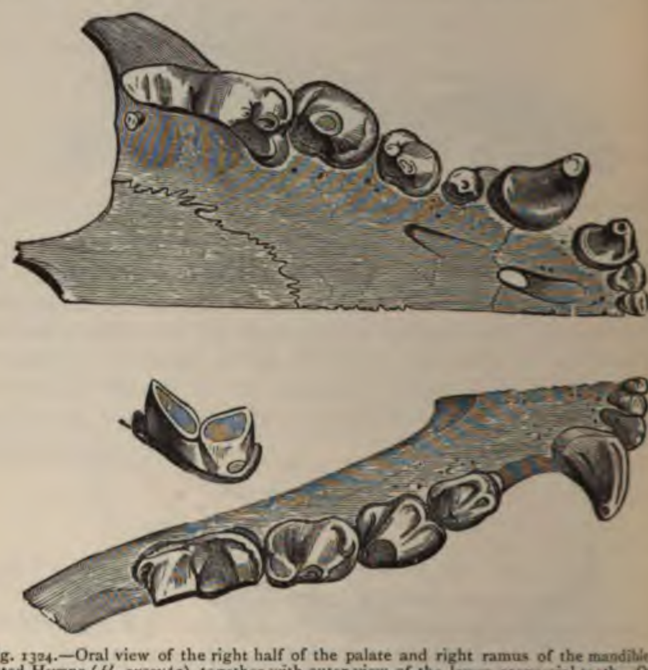


Fig. 1324.—Oral view of the right half of the palate and right ramus of the mandible of the Spotted Hyæna (*H. crocuta*), together with outer view of the lower carnassial tooth. One-half natural size.

so close that it is impossible to give a distinctive diagnosis of the family. Usually, however, there is but a single upper true molar, which is of small proportionate size, and is generally placed more or less entirely on the inner side of the carnassial; the latter tooth (fig. 1325) always having three distinct lobes to the blade, and a well-developed inner tubercle. The lower carnassial, or first true molar (fig. 1324) has a very large blade, and the hind talon com

[1] This is exclusive of *Ælurodon* (*Prohyæna*) and *Hyænocyon*, which D Schlosser transfers from the *Ursidæ* to this family.

paratively small; while its inner cusp, if present, is likewise relatively small. There is never more than one lower molar ($\overline{m.\ 2}$) behind the carnassial, and if present that tooth is very small. In the existing genus the humerus has no entepicondylar foramen, while, at least in the living species, each foot has but four digits, of which the claws are non-retractile. The most generalised member of the family is the genus *Palhyæna*, of the Lower Pliocene of Greece, France, and Persia, which has been included by many writers in *Ictitherium*, but of which the carnassial teeth are essentially those of a Hyæna. The dental formula is $I.\ \frac{3}{3},\ C.\ \frac{1}{1},\ Pm.\ \frac{4}{4},\ M.\ \frac{2}{2}$, or the same as in *Viverra*. The first upper true molar is placed entirely on the inner side of the large carnassial; the lower carnassial, except for its rather larger talon, is almost indistinguishable from that of the Striped Hyæna, while the second lower true molar is comparatively small. The first lower premolar is very minute, and in their compressed crowns the other premolars are more like those of *Viverra* than those of existing Hyænas. The type species is comparatively small, with slender jaws, and the muzzle is elongated after the Viverroid fashion. The imperfectly known *Lepthyæna*, of the Indian Siwaliks, is closely allied to, if not identical with, the preceding genus. The remaining forms may be included in the genus *Hyæna*, which may be divided into groups corresponding to the genera of some writers, although there is an almost complete transition from one to the other. In all cases there is never more than a single upper true molar, while in existing forms the normal dental formula is $I.\ \frac{3}{3},\ C.\ \frac{1}{1},\ Pm.\ \frac{4}{3},\ M.\ \frac{1}{1}$. In some fossil forms, however, the first upper premolar may be absent, while in others there may be a small first lower premolar or a second lower true molar.

Of the more generalised forms classed in the *Lychyænine* group (*Lychyæna*), as represented by *H. macrostoma* of the Pliocene of India, and *H. chæretis* of that of Greece and Samos, the muzzle is long, the premolars, of which there are four in the lower jaw, are compressed, the first upper true molar is placed partially behind the carnassial, the lower carnassial has an inner cusp, and there was probably a second lower true molar. In the *Hyænictine* group (*Hyænictis*), which likewise occurs in the Pliocene of India and Europe, the second lower true molar is still retained as a very minute tooth, but the premolars are more like those of existing forms, and the comparatively large $\overline{m.\ 1}$ is placed entirely on the inner side of the carnassial. The muzzle is also comparatively short. In the Indian *H. sivalensis* the first lower premolar is lost, although retained in the European *H. chæretis*. This group forms, indeed, a complete

connection between *Palhyæna* and the next group. In the typi
or *Euhyænine* group, as represented by the living Indian Strip
Hyæna (*H. striata*) the premolars form blunt cones admira
adapted for crushing large bones. In this group the upper
nassial (fig. 1325) has a short third lobe, while the correspond

Fig. 1325.—The right upper carnassial tooth of *Hyæna striata*, from the outer (A) and oral (B) aspects; from the Suffolk Crag.

lower tooth still retains its inner cusp and distinct hind talon
the first lower premolar and second true molar have totall
appeared. Remains referred to the existing species occur i
Suffolk Crag, the caverns of France and the Upper Plioce
Pleistocene of Italy. *H. arvernensis*, of the Upper Plioce

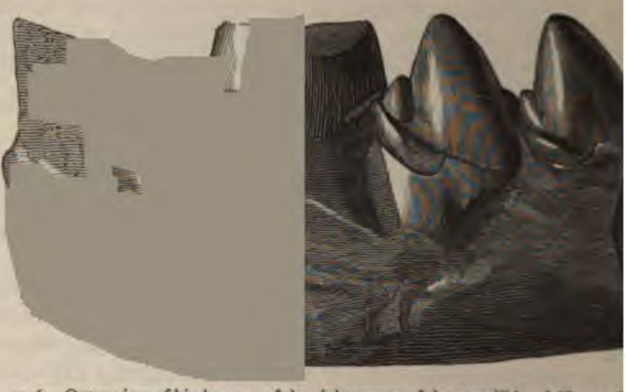


Fig. 1326.—Outer view of hinder part of the right ramus of the mandible of *Hyæna C*
from the Pliocene of India.

France and Italy, seems to be allied to *H. brunnea* of the
while *H. Perrieri* (*topariensis*), of the same deposits makes a
step towards *H. crocuta*, having lost the inner cusp to *m.* 1.
most specialised or *Crocutine* group (*Crocuta*) is now represen
the Spotted Hyæna, and is characterised by the long third

per carnassial (fig. 1327, A), and by the loss of the inner nd reduction in the size of the hind talon of the lower carnas- g. 1327, B).

most generalised representative of this group is *H. eximia*, Lower Pliocene of Greece and Persia, in which the first lower lar is retained, but the second lower true molar is lost, as in other members of this group.[1] *H. Colvini* (fig. 1326) of the

327.—(A), Palatal view of right upper carnassial and true molar; and (B), Outer view of right lower carnassial of *Hyæna crocuta*.

Siwaliks, in which *pm.* 1 has disappeared, may probably be ed as the ancestor of the existing Spotted Hyæna (*H. crocuta*); *H. robusta*, of the Upper Pliocene of Italy, is allied to *H. i*, but retains *pm.* 1.

Spotted Hyæna is now found in South Africa, but occurs in a fossil the Pleistocene of both Europe and India. It is characterised minute size of the upper true molar (fig. 1327), and the extremely size of the hind talon of the lower carnassial (*ibid.*) The facial the cranium (fig. 1328) is very broad and short.

ains of the Spotted Hyæna occur in vast quantities in many an cave-deposits; and were especially abundant in the celebrated le cave in Yorkshire, explored in the early part of this century by Buckland, and also that of Gailenreuth in Franconia. That these were dens in which the Hyænas dwelt is evident from the marks r teeth on the bones of other animals dragged in by them for s well as by other unmistakable evidence.

ILY FELIDÆ.—The *Felidæ*, in which the *Nimravidæ* of Pro- Cope are included, are the most specialised representatives of tire order; this being especially shown in the existing forms shortness of the skull, in which there is no alisphenoidal

[1] skull of the Spotted Hyæna in the College of Surgeons there is a second ue molar on one side.

and two lower true molars, and the circumsta
lower incisors are placed in the same horizont
exception all the known forms have an entepic

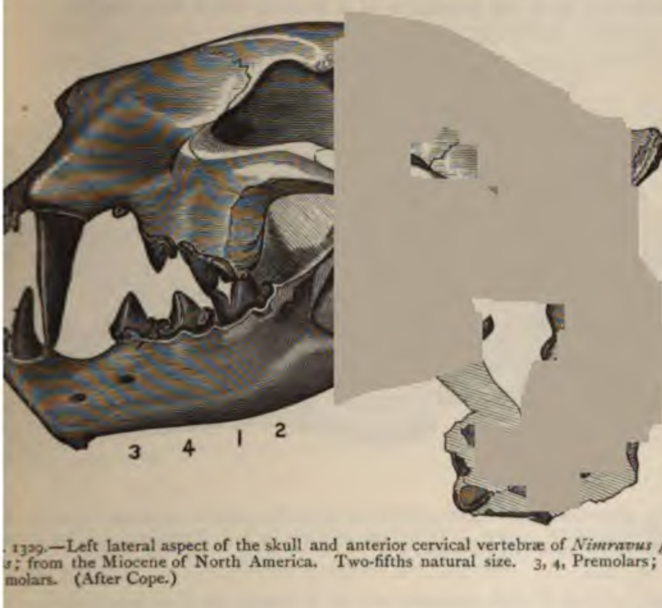
Fig. 1328.—Oblique lateral view of the cranium of *Hyæna crocuta*, Reduced. (After Owen.)

the humerus. This family was probably derived
of the modern *Viverridæ*, the view taken by Dr
true *Felidæ* are directly descended from the Cr
improbable. The earlier forms, constituting
Professor Cope, present generalised features wh
true Cats.

Here may be mentioned the remarkable gen
the Lower Miocene and Upper Eocene of Fran
small Carnivores of generalised affinities, which
by Professor Cope in the true *Felidæ* and by I
Mustelidæ. The skull agrees with that of C
possession of an alisphenoidal canal, and the
resemblances to those of that genus, the formula
being *Pm* 4 *M* 1 . The femur has a third t

ed by Dr Scott with *Cryptoprocta* in a separate family, but is placed by him in the *Nimravidæ*. The formula of the cheek- is $Pm. \frac{3}{3}$, $M. \frac{1}{2}$; the upper carnassial has no anterior lobe; lisphenoid canal is retained; the femur has a third trochanter; stragalus is flattened and articulates with the cuboid; and the inal phalangeals, although retractile, are not protected by bony ths. Generalised features are also displayed in the base of the ; and the bones of the skeleton approximate to those of *Cyno-* and other primitive types.

f the other generalised forms which may perhaps be included in family we may mention *Æluropsis* of the Pliocene of the Siwalik , and *Pseudælurus* typically from the Middle Miocene, but re- ed by Dr Filhol from the Upper Eocene Phosphorites of France. *ropsis* is very imperfectly known, but its mandible seems to oach that of the Machærodonts. Dr Schlosser would include in genus some of the forms from the French Phosphorites referred



. 1329.—Left lateral aspect of the skull and anterior cervical vertebræ of *Nimravus gom-s*; from the Miocene of North America. Two-fifths natural size. 3, 4, Premolars; 1, 2, molars. (After Cope.)

Dr Filhol to *Proælurus*, and would change the name to *Haplo-* , and place it in the *Mustelidæ*. The typical *Pseudælurus* has e lower premolars, and no inner cusp to the lower carnassial; in *P. intermedius*, which Dr Schlosser makes the type of the is *Stenogale*, there were four lower premolars in some instances,

in the Quercy Phosphorites of France, and has
from the Pliocene of India. The formula o

Pm. $\frac{3}{(3-4)}$, *M.* $\frac{1}{(1-2)}$; but it is not improbable
prove inseparable from *Nimravus* (fig. 1329), i
of lower premolars is reduced to two. Other al

North American Miocene are *Archælurus*, wit

Pogonodon (fig. 1330), with *Pm.* $\frac{3}{3}$, *M.* $\frac{1}{1}$; and
Pm. $\frac{(2-3)}{2}$, *M.* $\frac{1}{1}$. In addition to the general
premolars, and the presence of a second lower tr

Fig. 1330.—The right lateral aspect of the skull of *Pogonodon pl*
of North America. About two-fifths natural size. 2, 3, 4, Prem
Postglenoid process. (After Cope.)

ssrs Scott and Osborn, the hallux was well developed, there is a inct line in the scapholunar indicating the boundaries of the hoid and lunar, and the femur has a third trochanter; the two named features being regarded by the above-mentioned author- as inherited from a Creodont ancestor.

Turning to the true Cats we have, among existing forms, the nting-Leopard of India, forming the genus *Cynælurus*, which is inguished by its non-retractile claws: it may be represented the Pliocene of India. All the other "Cats" may be included the genus *Felis*, although some writers have proposed to split p into several genera. This genus is spread over the temperate tropical regions of the greater part of the globe. Although re are five digits in the manus, the hallux of the pes is reduced a rudiment of its metatarsal; the scapholunar has lost all e of its primitive duality; and the third trochanter has like- e disappeared from the femur. The dental formula is usually , $C.\ \frac{1}{1}, Pm.\ \frac{3}{2}, M.\ \frac{1}{1}$; but in some instances there are only two er premolars, and occasionally there are three lower premolars as abnormality. The upper carnassial (p^3, fig. 1331) has three

1331.—Left lateral view of the dentition of the Lion (*Felis leo*). Reduced. i^3, 3d In- c, Canines; p^1-p^3, 2d, 3d, and 4th upper premolars; *m*, True molars; p^1, p^2, 3d and 4th premolars.

s and a small inner tubercle; while the corresponding lower h (*ibid.*, *m*) has no inner cusp or hind talon, although the latter epresented by a minute tubercle in the Lynxes. In Europe this us makes its first appearance in the Middle Miocene of France, in North America in the Upper Miocene or Lower Pliocene ip-Fork beds.

n the Pleistocene of Europe we meet with remains which cannot be inguished specifically from the existing Lion, although the fossil form been named *F. spelæa*. Remains of the Leopard (*F. pardus*) also occur in the Continental cave-deposits; while in the corresponding deposits of Gibraltar we meet with the Pardine Lynx (*F. pardina*); and in those of Bengal we find remains of the Jaguar (*F. onca*) and Ocelot (*F. pardalis*), which now inhabit the same regions. In the Pliocene Siwaliks

Fig. 1332.—Left lateral view of cranium (A), and larger view of an upper canine (B) of *Machærodus megantherеum*; from the Upper Pliocene of France. Reduced.

of India we meet with the huge *F. cristata*, which shows characters connecting it both with the Tiger and the Jaguar; and also smaller forms, one of which appears to have been closely allied to the existing *F. bengalensis*. In the Pliocene of North America large Cats were represented

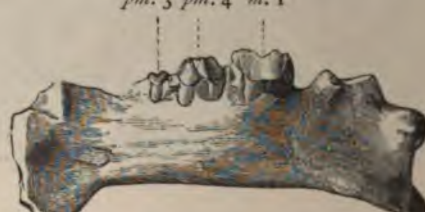


Fig. 1333.—Outer view of the left ramus of the mandible of *Machærodus sivalensis*; from the Pliocene of India. One-third natural size.

by *F. augusta* and *F. atrox*. In Europe, again, numerous species occur in the Pikermi beds of Greece; and we may also mention the comparatively small *F. arvernensis* and *F. issiodorensis*, of the French Pliocene, one of which probably also occurred in the corresponding deposits of Persia.

The most remarkable of the true Cats are, however, the extinct Machærodonts or Sabre-toothed Tigers, which are characterised by the enormous development of the upper canines of the males, by the presence of a deep descending flange in the mandibular symphysis for the protection of the latter, and the angulation of the anterior extremity of this symphysis; the structure of the carnassial teeth being usually of the type of those of the existing Cats. In the type genus *Machærodus* (fig. 1332), which may be taken to include *Smilodon*, *Drepanodon*, and *Trucifelis*, there are three incisors in each jaw; the premolars in the upper jaw never exceed two, and there may be either two or only one of these teeth in the lower jaw; the latter variation occurring in different individuals of a single species. The upper carnassial (fig. 1334) is usually like that of *Felis;* but in the South American *M. neogæus* (fig. 1335) it has four distinct lobes, and is thus the most complex example of this type of tooth that is known. This genus ranges in time from the Quercy Phosphorites to the Pleistocene, and is found in America, Europe, Persia, and India. The South American *M. necator* stands alone among the *Felidæ* in having no foramen to the humerus. The last genus of the family is the curious *Eusmilus*, of the Quercy Phosphorites, in which there are only two incisors and one premolar in the mandible, and the descending flange of the symphysis of the latter is of enormous depth. The existence of this extremely specialised form at such an early epoch is noteworthy; not less so being the total extinction of the Machærodonts, which, it has been suggested, may be due to their excessive specialisation having rendered them incapable of obtaining their subsistence.

Fig. 1334.—Oral aspect of the left upper carnassial and true molar of *Machærodus sivalensis;* from the Pliocene of India.


Fig. 1335.—Right lateral view of the skull of *Machærodus neogæus;* from the Pleistocene of South America. Greatly reduced.

Suborder 3. Creodonta.—The members of the suborder Creodonta (or Carnivora Primigenia) are all extinct, and their serial position has led to much discussion. By some authorities they have been classed with the Polyprotodont Marsupials; from which, however, they differ by the presence of a complete milk-den-

while a third writer ranks them as an order of eq
existing Insectivora and Carnivora. Their rela
however, on the whole, to be decidedly nearest
vora, and they are accordingly here classed as
order. They undoubtedly, however, exhibit affini
ivora, from which they are distinguished by the C
their incisors and canines; while the remarkabl
isting between their cheek-teeth and those of t
Marsupials is probably indicative of a distinct ge
with that group. Mention has already been mad
blances to the Condylarthrous Ungulates.

The following are the chief characters of th
brain is of relatively small size; the fourth upper
first lower true molar are not differentiated as a
carnassials, but resemble more or less closely the
behind or in front of them, which is either conic
less secant type; and the upper true molars are ei
or simply secant. The tibial face of the astrag
generally devoid of a groove; the scaphoid and
separate; the femur has a third trochanter; and t
tigrade. In all cases where there is the full numb
second pair in the lower jaw is thrust up above th
so many of the Carnivora Vera. The structure o
proximates to that of ***Amphicyon.***

FAMILY HYÆNODONTIDÆ.—This family include
ised forms. The dentition (fig. 1336) is of a
type, the inner tubercle of the hinder upper cheel
small; and there is no inner cusp to the lower
the type genus the scaphoid and lunar of the ca

Hyænodon has the dental formula $I.\ \frac{3}{3},\ C.\ \frac{1}{1},$ *I*

inner tubercle of the two upper true molars is al 'pper Miocene of North America is remarkable as being the only nown Mammal, except certain Edentates and Cetaceans, in which e pterygoids unite beneath the nasal passage. One of the Euro-ean forms was originally described as *Taxotherium*. In the allied *terodon*, which, together with *Oxhyæna*, some writers refer to a stinct family, the third upper true molar is present, and has a

ig. 1336.—Right lateral aspect of the dentition of *Hyænodon horridus*, wanting the teeth in ance of the second lower premolar; from the Miocene of North America. Reduced. (After idy.)

ansversely elongated crown; there may be either two or three pper incisors, and the first lower premolar is sometimes absent. he first and second upper true molars differ from those of *yænodon* by the large size of their inner tubercle, and the last ue molar is like the second; the cranium in many respects sembles that of *Amphicyon*. This genus is represented by

Fig. 1337.—The left side of the anterior half of the palate of *Oxhyæna galliæ*; from the French Phosphorites.

ree comparatively large species from the Upper Eocene (Lower ligocene) of Europe. An allied form, from the French Phos-horites, has been named *Pseudopterodon*, and connects the former nus with *Theuritherium*. The remarkable genus *Oxhyæna*, of the orth American Eocene and the French Phosphorites, has an elon-ated mandibular symphysis, with the dental formula $I. \frac{(2-3)}{0}$, . $\frac{1}{1}$, $Pm. \frac{4}{4}$, $M. \frac{2}{2}$; the species figured in the woodcut having only two upper incisors. *Protopsalis* is another Eocene American genus; while *Hemipsalodon*, from the White River Miocene of Canada, is the largest form yet known in the suborder, and has the full typical Eutherian dentition.

FAMILY PROVIVERRIDÆ.—The members of this family (fig. 1338) are characterised by the large size of the inner tubercle of the upper

Fig. 1338.—Skull (*a*, *b*, *c*) and tarsus (*d*) of *Proviverra Whitiæ*; from the Wasatch Eocene of Wyoming, U.S.A. Two-thirds natural size.

true molars, and by the presence of an inner cusp to the blade of those of the lower jaw. The type genus *Proviverra* (*Cynohyænodon* or *Stypolophus*) occurs in the Upper Eocene of both Europe and North America; one of the European forms being from the Quercy Phosphorites. The skull (fig. 1338) is elongated, and the lower true molars, which are differentiated into a blade and a hinder tubercular talon, closely resemble the lower carnassial of *Dasyurus* (fig. 1145) among the Marsupials, and of *Cynodictis* and *Viverra* in the Carnivora Vera, and thus indicate how the latter group has in all probability been derived from a form allied to the present family; the hinder lower molars of the Carnivora Vera having become tubercular and non-secant. Other members of this family found in the Lower, or Puerco, Eocene of North America are *Deltatherium*, *Chriacus*, and, according to Professor Cope, *Mioclænus*, and probably *Triisodon* and *Onychodectes*. *Didelphodus*, from the higher Eocene of America, may also be placed here, as well as *Quercytherium*, from the French Phosphorites, and perhaps *Galethylax*, of the Paris Eocene. *Conoryctes* and *Hemiganus* are allied Puerco types; the latter being distinguished by the fusion of the roots of the upper true molars, and hence regarded by Professor Cope as the type of a distinct family showing signs of affinity with the Tillodontia.

FAMILY ARCTOCYONIDÆ.—This family is typified by the genus *Arctocyon*, of the Lower Eocene of France, with which may be classed *Hyodectes* and *Heteroborus*, of the Lower Eocene of Rheims. Dr Schlosser suggests that *Mioclænus* should come in this family.

FAMILY MESONYCHIDÆ.—The members of this family are short-jawed forms, usually having the typical number of teeth, which are less different than in the other families from those of the Carnivora Vera. The type genus *Mesonyx*, from the North American Eocene, has a grooved astragalus; and other genera which are referred to this family are *Dissacus*, *Sarcothraustes*, and *Patriofelis*, from the latter area, and not improbably *Theuritherium*, of the French Phosphorites. *Dissacus* has, however, no trochlea to the astragalus, and is therefore nearer to the *Proviverridæ*. *Amblyctonus*, of the North American Eocene, is an allied form with the astragalus not grooved, on which account it has been regarded as the type of a distinct family. *Palæonictis*, of the Lower Eocene of France, may be allied.

FAMILY UNCERTAIN.—A few genera cannot at present be definitely placed. These comprise *Thylacomorphus*, from the French Phosphorites, which it has been suggested may be identical with *Proviverra;* and *Dasyurodon*, or *Apterodon*, from the Lower Miocene (Middle Oligocene) of Flonheim, which Dr Schlosser thinks may turn out to be the same as *Oxhyæna galliæ*. *Dromocyon*, of the Bridger Eocene, is not improbably founded upon a very old individual of *Mesonyx;* while the imperfectly known *Argillotherium*, from the London Clay, may prove to be identical with one of the American genera. Finally, it should be mentioned that Dr Schlosser would place in this suborder the genus *Platychærops*, which is here classed with the Tillodontia.

CHAPTER LXIII.

CLASS MAMMALIA—continued.

ORDERS INSECTIVORA, CHIROPTERA, AND PRIMATES.

ORDER IX. INSECTIVORA.—The Insectivora are a group of small Mammals, not very readily defined from the characters of their bones and teeth. The teeth are well developed, and generally easily separable into the usual four divisions, although in certain cases the distinction between incisors, canines, and premolars is not very clear. The dentition is diphyodont and heterodont; the cheek-teeth are always rooted, and their crowns carry a number of minute pointed cusps; the crowns of the upper true molars being either subquadrangular or triangular in shape. The first pair of incisors in some cases are not in contact in the middle line; and the canines are often weak. The zygomatic arches of the skull are usually either weak or entirely absent; clavicles are present in all existing forms except *Potamogale;* in the carpus the scaphoid and lunar are separate; the feet are usually either entirely or partially plantigrade, and their digits are generally five in number, with the terminal phalangeals unguiculate, narrow, and subcylindrical. Certain Insectivores, such as the Moles and *Galeopithecus*, are remarkable as being the only Mammals in which ossified vertebral intercentra are known to have been developed in the dorso-lumbar region. As a rule the humerus has a foramen.

Fossil forms apparently indicate a relationship on the one hand with the Creodont Carnivora, and on the other with the Lemuroid Primates; those genera with square-crowned upper true molars approximating to the latter group, while those in which the crowns of these teeth are triangular show the nearest affinity to the former. Dr Schlosser concludes, with great probability, that the Lemuroids, Insectivores, and Creodonts are all diverging branches from a common stock, which may also have given origin to the Condy-

[...]arthrous Ungulates. The resemblance of the molars of *Tupaia* to those of the Marsupial genus *Perameles*, and that between the same teeth in the Creodonts and the *Dasyuridæ*, further suggests the connection of this common stock with the ancestral types of the Polyprotodont Marsupials.[1] The Insectivores agree with the Lemuroids not only in dental characters, but also in the presence of clavicles, in their plantigrade feet, and the discoidal placenta; and it is indeed quite evident that the ancestral stock of the Primates must have been provided with complete clavicles.

This order may be divided into the suborders Insectivora Vera and Dermoptera. The former may be further subdivided into two sections, in the first of which the molars have broad and squared crowns, with their cusps frequently arranged like the letter W, while in the second section the crowns of these teeth are narrow and V-shaped, with the apex of the V directed inwardly (tritubercular). The Dermoptera, represented only by the volant genus *Galeopithecus*, are unknown in a fossil condition. It should, however, be observed that this genus, although not on the direct line of descent, indicates the manner in which the Insectivores have become modified into the Bats. The first section of the Insectivora Vera comprises the existing *Tupaiidæ*, *Macroscelididæ*, *Erinaceidæ*, *Soricidæ*, and *Talpidæ*, together with the extinct *Microchœridæ* and *Dimylidæ*.

FAMILY TUPAIIDÆ.—The Tupaias are small arboreal Insectivores confined at the present day to the Indo-Malayan region. The genus *Parasorex*, from the Middle Miocene of the Continent, has the dental formula $I.\ \frac{3}{3},\ C.\ \frac{1}{1},\ Pm.\ \frac{4}{4},\ M.\ \frac{3}{3}$, and may be provisionally placed in this family, although, according to Dr Schlosser, it approximates in several respects to the *Macroscelididæ*. There is one more upper incisor and one more premolar in each jaw than in *Tupaia*, and the last two premolars are somewhat more complex. The above-mentioned writer regards this genus as the representative of a group connecting the *Tupaiidæ* of Asia with the *Macroscelididæ* of Africa. An Insectivore from the Middle Miocene of Sansan, described as *Lantanotherium*, is said to be very nearly allied to *Tupaia*.

FAMILY ERINACEIDÆ.—Since the *Macroscelididæ* are at present unknown in a fossil state, we may pass to the *Erinaceidæ* or Hedgehogs. In the typical genus *Erinaceus* (fig. 1339) the dental formula is $I.\ \frac{3}{2},\ C.\ \frac{1}{1},\ Pm.\ \frac{3}{2},\ M.\ \frac{3}{3}$; the first pair of upper incisors are large,

[1] On embryological grounds some authorities are disposed to regard the Marsupials as being off the line of Eutherian ancestry; but it must be borne in mind that the evidence only includes existing types.

and separated from one another by a space, the five succeeding teeth small and conical, the last premolar and the two first true molars broad and cusped, while the last tooth is very small; and there is a vacuity on either side of the hinder part of the palate. The existing *E. europæus* has been found fossil in the Pleistocene; a small species occurs in the Upper Miocene of Œningen, in Switzer-

Fig. 1339.—Left lateral view of the skull of the Hedgehog (*Erinaceus europæus*).

land, and others are found in the Middle Miocene of France. In the Lower Miocene of the same country occurs the genus *Palæoerinaceus*, distinguished from *Erinaceus* by the absence of vacuities in the palate, and the greater relative width of the latter. An apparently allied form from the French Miocene has been described by Gervais under the name of *Erinaceus arvernensis*, which is, however, not the same as *E. arvernensis* of De Blainville. From the Quercy Phosphorites there have been obtained remains of other members of this family more nearly allied to the existing *Gymnura* of Madagascar, but presenting characters which also link them very closely with *Erinaceus* through *Palæoerinaceus*. These Quercy forms have been referred to three genera under the names of *Neurogymnurus*, *Cayluxotherium*, and *Comphotherium*, but it appears probable that the second is a synonym of the first. The teeth of *Neurogymnurus* and *Cayluxotherium* are like those of *Gymnura*, but the palate has vacuities as in *Erinaceus; Comphotherium* is distinguished by a cingulum to the lower true molars, which also occurs in *Gymnura*. *Neurogymnurus* has also been recorded from the Upper Eocene of Hampshire.

Fig. 1340.—Palatal view of the right upper cheek-dentition of *Microchœrus erinaceus;* from the Upper Eocene of Hordwell.

FAMILY MICROCHŒRIDÆ.—The genus *Microchærus* (fig. 1340), from the Upper Eocene of Hordwell, with which *Heterohyus*, of the corresponding beds of France, may be identical, agrees with *Erinaceus* in showing an interval between the first upper incisors of either side, and may be provisionally placed in this order. It has en regarded as allied to the Lemuroid *Hyopsodus*, but Professor sborn states that it is really very different. The dental formula y be given approximately as $I. \frac{2}{?}, C. \frac{1}{1}, Pm. \frac{3}{?}, M. \frac{3}{3}$. The two per incisors have compressed crowns, somewhat like those of the succeeding teeth; but the last two premolars and the true molars e broad and flat crowns, carrying a number of small cusps.

FAMILY DIMYLIDÆ.—This family is proposed by Dr Schlosser the genera *Dimylus* and *Cordylodon;* two minute Insectivores n the European Miocene which appear to be related to the *naceidæ*.

AMILY SORICIDÆ.—The *Soricidæ*, or Shrews, are readily characsed by their dentition, in which the first upper incisor is large furnished with a basal tubercle, while between it and the last nolar there are a variable number of small incisors and premo- together with the equally minute canine. In the mandible the ber of teeth is always *I.* 1, *C.* 1, *Pm.* 1, *M.* 3; the incisor being livous and much produced forwards, and the canine the smallest h of the series. Existing species of *Sorex*, and perhaps of *Crosso-* occur in the Norfolk Forest-bed, while a species of the former us, regarded as extinct, has been recorded from the Pleistocene ccias of Sardinia. Existing species of *Sorex* or *Crocidura* also ur in the caverns of Madras. Numerous forms have been re- ded from the Continental Tertiaries, ranging from the Miocene the Quercy Phosphorites, some of which are referred to *Sorex*, le others, such as the Quercy species, have been regarded as erically distinct, and named *Amphisorex*. Dr Schlosser thinks t *Orthaspidotherium* and *Pleuraspidotherium*, mentioned on p. 88, might be placed here.

FAMILY TALPIDÆ.—The *Talpidæ*, or Moles and Desmans, are sely allied to the *Soricidæ*, although easily distinguished by the n-production of the first lower incisor; they are usually of fos- ial, but in some cases are of natatorial habits. This family is ided into the *Myogalinæ* and the *Talpinæ;* in the former the merus and clavicle being moderately elongated. In this sub- nily the aquatic type genus *Myogale*, in which the dentition (fig. 41) is $I. \frac{3}{3}, C. \frac{1}{1}, Pm. \frac{4}{4}, M. \frac{3}{3}$, is represented in the Norfolk rest-bed by the existing Desman (*M. moschata*), of the rivers of ssia; the fossil form having been originally described under the me of *Palæospalax*. Remains of this genus have also been ob- ned from the Middle and Lower Miocene of France. *Tetracus*, m the Lower Miocene of Ronzon, near Puy-en-Velay, is a small sectivore apparently presenting affinities both with *Myogale* and *rinaceus;* and allied to this genus are two other imperfectly known

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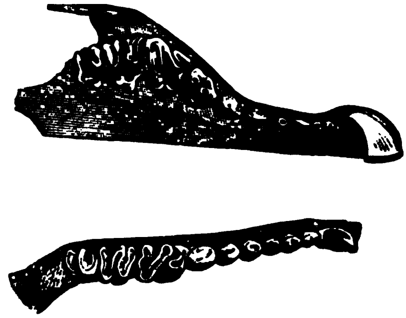

Fig. 1341.—Palatal view of right upper and lower dentition of *Myogale moschata*. Europe.

genus *Urotrichus* of Japan and North America
subfamily, or *Talpinæ*, in which the humerus a
enormous relative breadth, the typical genus *Ta*
the same dental formula as in *Myogale*. The
europæa, occurs fossil in the Norfolk Forest-bec
from the Pleistocene breccia of Sardinia is reg
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The genus i
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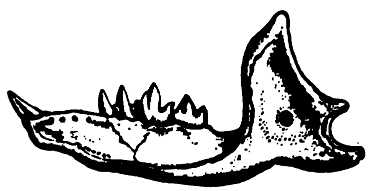

Fig. 1342.—Left ramus of lower jaw of *Plesiosorex soricinoides*, wanting the last true molar and the teeth between the first incisor and the fourth premolar; from the Lower Miocene of the Auvergne. Twice natural size. (After De Blainville.)

'AMILY ADIPOSORICIDÆ.—This family contains the minute *Adipo-*r and *Adiposoriculus*, from the Lowest Eocene of Rheims, which ;chlosser regards as related to the Shrews, but forming a distinct ly, attaining a higher degree of development.

AMILY LEPTICTIDÆ (ICTOPSIDÆ).—The second section of the :tivora Vera includes the recent families *Potamogalidæ*, *Soleno-*'*dæ*, *Centetidæ*, and *Chrysochloridæ ;* and we may provisionally in the same neighbour- the family *Leptictidæ* of North American Eocene Miocene. The latter s are regarded by Dr osser as true Insectivora, ugh they were placed Professor Cope near the *nodontidæ*. The family ides the genera *Leptictis*, *ndectes*, *Ictops*, and per- *Geolabis*.

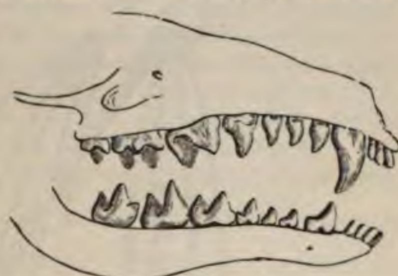

Fig. 1343.—Lateral view of right dentition of the Mole (*Talpa europæa*). Enlarged.

inally the names *Cente-*n, *Entomodon*, *Entomacodon*, *Centracodon*, and others have been ied to the remains of small entomophagous mammals from the er Tertiaries, of which the serial position is doubtful.

RDER X. CHIROPTERA.—The Chiroptera are characterised by fact that the anterior limbs are longer than the posterior, the ts of the fore limb, with the exception of the pollex, being enor-isly elongated (fig. 1344). These elongated fingers are united an expanded membrane or patagium, which is also extended ween the fore and hind limbs and the sides of the body, and in ny cases passes also between the hind limbs and the tail. The agium thus formed is naked, or nearly so, on both sides, and ves for flight. In the manus the pollex, and sometimes the next it as well, is unguiculate, or furnished with a claw; but the other its are destitute of nails. In the hind limbs all the toes are guiculate, and the hallux is not in any respect different from other digits. Well-developed clavicles are always present, and radius has no power of rotation upon the ulna. The four ids of teeth are always present (although the molars are aborted *Desmodus*), and the dental formula is never known to exceed

$\frac{2}{3}$, *C.* $\frac{1}{1}$, *Pm.* $\frac{3}{3}$, *M.* $\frac{3}{3}$.

This order, which is evidently a branch from the Insectivorous ck, is divided into the suborders Megachiroptera and Micro-iroptera. The former, which is characterised by the possession smooth cheek-teeth, marked by a longitudinal groove, comprises

the *Pteropodidæ*, or Fruit-bats, and is unknown in a fossil con
In the latter, which comprises all other Bats, the teeth are c
with minute pointed cusps; nearly all the species being o
paratively small size. The most remarkable feature presen
the past history of this order is the occurrence of forms

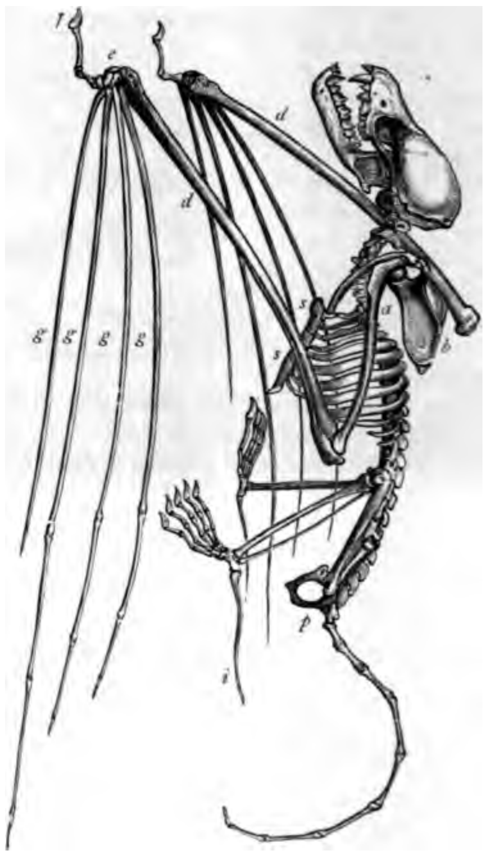

Fig. 1344.—Skeleton of the Mouse-coloured Bat (*Vespertilio murinus*). *a*, Hur
Scapula; *d*, Radius, with the rudimentary ulna at its proximal end; *e*, Carpus; *f*, Po
Metacarpals; *s s*, Sternum; *p*, Pelvis; *i*, Supplementary bone attached to the calcane

allied to those of the present day as low down as the
Eocene of North America, which indicates that the charac
features of the order were probably acquired at a peri
later than the Lower Eocene or Cretaceous epoch. The fo
families of *Microchiroptera* may be noticed:—

FAMILY RHINOLOPHIDÆ.—In the existing genera of this family dental formula never exceeds *I.* $\frac{1}{2}$, *C.* $\frac{1}{1}$, *Pm.* $\frac{2}{3}$, *M.* $\frac{3}{3}$, and the e carries a peculiar leaf-like expansion. The type genus *Rhin-phus*, in which the dental formula is as above, is represented in cave-deposits of Europe by remains of existing species. Two s, from the Upper Eocene Phosphorites of France, have been rred to this genus under the names of *R. dubius* and *R. antiquus*, the latter species is regarded by some authorities as entitled to eric distinction, and the term *Pseudorhinolophus* has accordingly n proposed for its reception. *Alastor*, from the same deposits, n extinct genus characterised by the extreme shortness of the l region and other features of the skull. *Palæonycteris*, from Lower Miocene of France, is stated to be allied to *Rhinolophus*, the premolars are $\frac{3}{3}$, and the limb-bones are said to resemble se of the South American *Molossus*. *Phyllorhina*, in which the molars are $\frac{(1-2)}{2}$, is represented by the living oriental *P. diadema* he Pleistocene cave-deposits of Madras, and perhaps by a species he Quercy Phosphorites.

FAMILY VESPERTILIONIDÆ.—In the *Vespertilionidæ* the nose does carry a distinct follicular appendage, the number of incisors is ally $\frac{(1-2)}{3}$, and in some genera there are three premolars in each . Of *Plecotus*, the existing *P. auritus* occurs in the cavern-posits of Europe. *Vesperugo*, with incisors usually $\frac{2}{3}$, and pre-lars $\frac{2}{2}$, is perhaps represented in the Upper Eocene of the Paris sin by the well-known *V. parisiensis*, which appears closely allied the existing *V. serotina*, although generically separated by some iters under the name of *Nyctitherium*. This genus has also been scribed from the Eocene of North America, where it is repre-ted by several species, ranging as low down as the Bridger rizon, some of which have been described under the name of *ctitherium*. *Nyctilestes serotinus*, from the same deposits, is the e of an allied genus. Remains of the existing *V. noctula* (fig. 45) occur in the English Pleistocene. In the type genus *Vesper-o* the dental formula is *I.* $\frac{2}{3}$, *C.* $\frac{1}{1}$, *Pm.* $\frac{3}{3}$, *M.* $\frac{3}{3}$. The existing *murinus* occurs in the cave-deposits of France, and a considerable mber of species have been referred to this genus from the Middle rtiaries of the Continent, but the generic reference must be considered in some instances as open to doubt. Among these may be mentioned *V. murinoides*, from the Middle Miocene of France, and *V. precox* and *V. insignis*, from the Lower Miocene of Germany. A Bat from the Quercy Phosphorites originally named *V. Bourguignati* has been made the type of a distinct genus *Vespertiliavus*,

Fig. 1345.—*Vesperugo noctula*.[1] Skull, scapula, and fore and hind limbs; from a fissure in the Mendip Hills.

and differs from *Vespertilio* in the proportions of the premolars. Remains of numerous existing members of this family have been recorded from European caverns.

FAMILY EMBALLONURIDÆ.—This is an extensive family showing great variation in the number of the teeth, and mainly characterised by the nose and muzzle being devoid of expansions, and by certain peculiar features connected with the tail. All its members at the present day are confined to tropical and subtropical regions. In *Taphozous*, of which the dental formula is $I. \frac{1}{2}, C. \frac{1}{1}, Pm. \frac{2}{2}, M. \frac{3}{3}$, remains of the existing *T. saccolæmus* occur in the cave-deposits of Madras; and Dr Weithofer considers that certain humeri from the Quercy Phosphorites may indicate the occurrence of this genus in the Upper Eocene. In the Brazilian cave-deposits we meet with remains of a *Molossus* (*Dysopes*), probably identical with the living *M. Temmincki* of the same region.

FAMILY PHYLLOSTOMATIDÆ.—The last family is that of the *Phyl-*

[1] In the previous edition this figure was wrongly named *V. parisiensis*.

idæ, now confined to tropical America, and distinguished by ence of cutaneous expansions in the nasal region, as well as culiarity in the number of the digits of the manus. In this the existing *Vampectrum*, having the formula $I. \frac{2}{2}, C. \frac{1}{1}, M. \frac{3}{3}$, together with undetermined spe- *Phyllostoma* (fig. in which the pre- are $\frac{2}{2}$, occur in the eposits of Brazil. ly enough the man- a large Bat, from ercy Phosphorites,

Fig. 1346.—Lateral view of the skull of the Javelin Bat (*Phyllostoma hastatum*).

d under the name of *Necromantis*, appears to indicate the ice of this family in the European Eocene.

nclusion it should be observed that Professor Cope thinks mall Mammal from the Miocene of North America, which lescribed under the name of *Domnina*, may possibly belong Chiroptera.

R XI. PRIMATES.—This, the highest order of Mammals, es the Lemurs, Monkeys, Baboons, Apes, and Man. The e unguiculate, and usually five in number; and in existing ith the exception of Man, the hallux is opposable to the igits. The pollex may be wanting, but when present is opposable to the other digits of the manus. The dentition odont and heterodont. In the existing and the allied extinct the incisors are usually $\frac{2}{2}$, and the true molars (with the n of the *Hapalidæ*) $\frac{3}{3}$ in number. The crowns of the cheek- e, moreover, always adapted for grinding, and those of the lars generally consist of four tubercles, or cusps, which may e simple, or modified so as to form imperfect transverse r crescents; but some extinct types have tritubercular upper

structure of the premolars is always simpler than that of molars; and in many Lemuroids the anterior lower pre- ssumes the form and functions of a canine, as in the *Coty-* fig. 1347). All existing forms have the orbit entirely sur- by bone; while complete clavicles are present, and there is no entepicondylar foramen to the humerus, nor a third trochanter to the femur. The terminal phalangeals of the digits are flattened. In the soft parts there is a discoidal placenta, as in the Insectivora.

In our present state of knowledge, it is difficult to draw a line between the more generalised fossil representatives of this order and the Insectivora. Some remarks on the probable origin of the Primates have been already made under the head of the last-named order, while others are added below.

SUBORDER I. LEMUROIDEA.—The existing members of this group differ in many respects from the following suborder, but attention may be directed mainly to certain osteological and dental characters. Thus the skull (fig. 1347) has a somewhat produced muzzle; the orbits are not closed behind by bone, but open freely beneath the post-orbital bar into the temporal fossa; and the lachrymal foramen is situated on the outer surface of the skull, instead of within the orbit. The nostrils have a peculiar twist on the outer side. The incisors vary much in the different families, but they are frequently separated in the middle line, and are usually $\frac{2}{2}$ in number, although they are reduced to $\frac{1}{1}$ in *Chiromys;* those of the lower jaw being frequently procumbent. Canines are present except in *Chiromys.* The number of premolars varies from $\frac{1}{0}$ in *Chiromys* to $\frac{4}{4}$ in the extinct *Adapis*, but is generally either $\frac{2}{2}$ or $\frac{3}{3}$; while frequently the second lower premolar is larger than either of the following teeth. The outer tubercles of the upper true molars (fig. 1349) are laterally flattened, while the inner ones form imperfect crescents; and in the lower molars the tubercles likewise form a pair of imperfect crescents. The second digit of the pes has a long claw-like nail, but all the other digits have nails; the digits themselves being five in number, and the long pollex being generally opposable. The brain has but few convolutions, and the cerebellum is only partially covered by the cerebrum.

Fig. 1347.—Left lateral aspect of the skull of the Slow Loris (*Nycticebus tardigradus*); from the Malayan region. The tusk-like tooth in the lower jaw is the second premolar. (After Giebel.)

Many of the foregoing characters are common to other orders, such as the Insectivora. In the case of fossil forms it appears, indeed, that the Lemuroids can only be distinguished from the Insectivores by the absence of the cleft in the terminal phalangeals of the digits, so that when these are unknown it is frequently very difficult, if not impossible, to determine to which order such forms should be referred. Since, moreover, as we have stated under the head of the Insectivora, it is probable that Insectivores and Lemuroids are descended from the same ancestral stock we must expect to find the characters common to the two groups increasing in importance and number as we recede in time. By Professor Cope the Lemuroids are, however, regarded as closely allied to the Condylarthrous Ungulates; and that writer proposes to brigade together the Primates, Condylarthra, and Hyracoidea under the common name of Taxeopoda; the Condylarthra being regarded as the ancestral type. Now although we may be prepared to admit the derivation of the Condlyarthra from the common stock which gave origin to the Insectivora and Primates (see p. 1455), yet the apparent absence of clavicles in all the known representatives of that group renders it at least premature to say definitely that it gave rise to the Primates. At the present day Lemuroids are confined to the warmer regions of the Old World, being especially characteristic of Madagascar and certain parts of Africa. The recent forms are divided into the families *Lemuridæ*, *Tarsiidæ*, and *Chiromyidæ*.

FAMILY HYOPSODONTIDÆ.—This family name was proposed by Dr Schlosser[1] for the reception of certain North American Eocene forms now looked upon by most writers as undoubted Lemuroids, although some of them have been classed among the Insectivora. The most generalised form is *Pelycodus*, from the Eocene of New Mexico, at one time regarded by Professor Cope as an Insectivore allied to *Tupaia*. Dr Schlosser states that it presents some affinity to the Insectivorous *Microchœrus*, which he places in the same family. *Hyopsodus* (fig. 1348), of the American Eocene, has the dental formula $I. \frac{2}{2}, C. \frac{1}{1}, Pm. \frac{4}{4}, M. \frac{3}{3}$; the third upper premolar is as well developed as the second, by which character it is readily distinguished from *Microchœrus*, to which it has been compared. Several species have been described, of which one comes from the Lower or Puerco Eocene, while the others are from the higher Wasatch and Bridger horizons. *Microsyops* is

Fig. 1348.—Palatal view of the left upper (*a*) and lower (*b*) dentition of *Hyopsodus vicarius*; from the Eocene of North America. (After Cope.)

[1] Wrongly given as *Hyopsodidæ*.

an apparently allied form from the North American Eocene said to have only three premolars. In *Pelycodus* the hallux was not opposable. There are a number of other names which have been applied to American forms of uncertain position, but since the synonymy is very complex nothing would be gained by quoting them here.

FAMILY LEMURIDÆ.—Passing to Lemuroids more closely allied to existing forms those extinct genera may first be noticed many of which exhibit the generalised feature of having four premolars in either jaw, on which grounds, coupled with certain slight differences in the form of the lower premolars, Dr Schlosser regards them as constituting a distinct family—the *Adapidæ*. We may, however, provisionally follow Professor Flower in including them in the *Lemuridæ*, of which they will form the subfamily *Adapinæ*. The best known of these forms is the type genus *Adapis* (*Aphelotherium*, or *Palæolemur*), from the Upper Eocene (Oligocene) of both France and England, in which the dental formula is $I. \frac{2}{2}, C. \frac{1}{1}, Pm. \frac{4}{4}, M. \frac{3}{3}$; the upper molars being of a quadritubercular type. The last upper premolar is as complex as the true molars, which (fig. 1349) resemble those of *Lepidolemur* and *Hapalemur*, while the skull makes the nearest approach to that of *Propithecus*. It has, indeed, been suggested that this and the allied genera show certain relationships to the Anthropoidea which are not seen in existing representatives of the suborder; but their alleged relationship to the bunodont Artiodactyla does not appear to be substantiated.

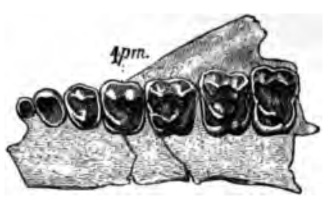

Fig. 1349.—Palatal aspect of the left upper cheek-teeth of *Adapis magna*; from the Upper Eocene of Hampshire.

The imperfectly known genus *Cænopithecus* from the Upper Eocene of Switzerland is regarded by Dr Schlosser as identical with *Adapis*, although Professor Rütimeyer considers that it is allied to the American *Pelycodus*. From the Eocene of North America we have the two nearly related genera *Tomitherium* and *Notharctus*. The former (with which *Limnotherium* of Professor Marsh is identical) is distinguished by the single roots to the premolars, and by the development of a third lobe to the last lower true molar. *Notharctus* agrees with *Adapis* in the presence of two roots to the premolars, but has a larger lower canine. *Thinolestes* and *Telmatolestes* are probably allied to or identical with the preceding genera; both being from the American Eocene.

Turning to the more typical representatives of the family, in which at least the upper premolars do not exceed three, we have the small

Necrolemur from the French Phosphorites, the dental formula of which Dr Schlosser gives as *I.* $\frac{2}{1}$, *C.* $\frac{1}{1}$, *Pm.* $\frac{3}{3}$, *M.* $\frac{3}{3}$, or the same as in the existing *Tarsius*, although he suggests that in some cases there may have been four lower premolars. The skull resembles that of the living genus *Galago* of Africa, both in size and structure, as is especially shown by the prominent auditory bullæ. The upper molars are also like those of one species of that genus, although the

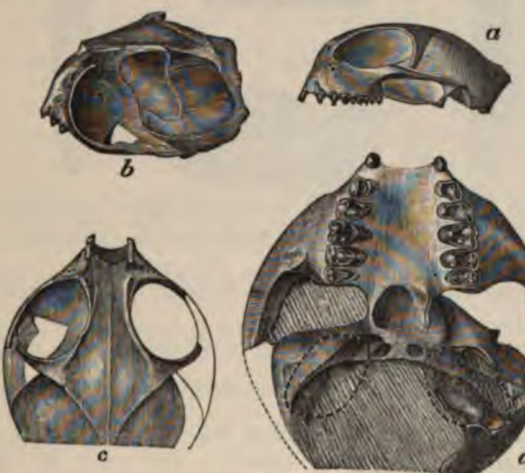

Fig. 1350.—Cranium of *Anaptomorphus homunculus*; from the Wasatch Eocene of North America. *a*, From the left side; *b*, Oblique view; *c*, From above; *d*, From below (enlarged). (After Cope.)

last premolar is distinguished by having only one outer column, and is accordingly simpler than the true molars. In this respect *Necrolemur* agrees with *Chirogaleus* of Madagascar.

Plesiadapis, from the Lower Eocene of Rheims, may be provisionally placed here. *Anaptomorphus*, from the Middle Eocene of North America, of which the cranium and mandible are shown in the accompanying figures, seems to be allied to *Necrolemur*, but has two lower incisors, and the upper premolars are unusually complex and approach those of the *Anthropoidea*. The upper molars are tritubercular; and Professor Cope gives the dental formula as *I.* $\frac{2}{2}$, *C.* $\frac{1}{1}$, *Pm.* $\frac{2}{2}$, *M.* $\frac{3}{3}$. *Cynodontomys* is an imperfectly known genus from the Wasatch Eocene; and *Mixodectes* an older one from the Puerco or Lower Eocene of North America. Dr Schlosser also regards the American Eocene genus *Omomys* as allied to *Necrolemur*, although it was considered by Professor Cope to be more nearly related to *Hyopsodus*. *Lemuravus*, of the American Eocene, may perhaps belong to the preceding division of this family.

The total absence of remains of Lemuroids from the Miocene of

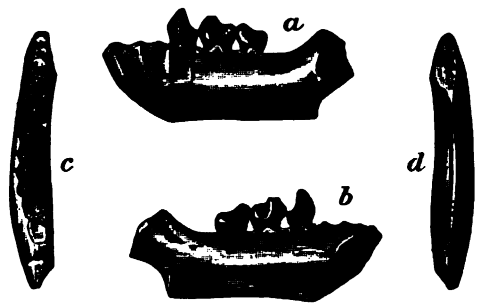

Fig. 1351.—Left ramus of the mandible of *Anaptomorphus æmulus*, wanting all the teeth except the last premolar and first two true molars; from the Bridger Eocene of North America. *a*, Outer; *b*, Inner; *c*, Upper; *d*, Lower view. Twice natural size. (After Cope.)

Europe and North America points to their early disappearance from those regions.

SUBORDER 2. ANTHROPOIDEA.—In all the known members of this suborder the number of the incisors is $\frac{2}{2}$; the upper ones being always in contact in the middle line, and the lower ones not projecting forwards to any great extent. The orbit is completely closed behind by bone; and the lachrymal foramen opens within its cavity. The pollex is short, and the second digit of the pes has a true nail. This suborder may be divided into the *Platyrhine* and *Catarhine* sections. In the former, which is confined at the present day to South America, the structure of the cheek-teeth is intermediate between that obtaining in the Lemuroidea and the succeeding section. The premolars are always $\frac{3}{3}$ in number, but the true molars may be either $\frac{2}{2}$ (*Hapalidæ*), or $\frac{3}{3}$ (*Cebidæ*); and the last lower true molar has a small hind talon. The nostrils are simple, widely separated, and placed nearly at the extremity of the snout. The pollex is either absent, or, if present, is not opposable; and there are other characteristic external features.

The genus *Laopithecus*, from the Miocene of North America, has been referred to this section, but its dentition approximates to that of the early Lemuroids, and its position must be regarded as unsettled.

FAMILY HAPALIDÆ.—In the Marmosets, which are nearest to the

Lemuroidea, two species of *Hapale* have been recorded from the cave-deposits of Brazil, one of which is regarded as extinct.

FAMILY CEBIDÆ.—The Brazilian cave-deposits have also yielded remains of various *Cebidæ* referable to the existing genera *Callithrix*, *Cebus*, and *Mycetes;* several of which appear indistinguishable from species still inhabiting the same region. A monkey allied to *Mycetes*, but of larger size than any existing species, has been referred to a distinct genus under the name of *Protopithecus*.

CATARHINE SECTION.—In this section, which comprises the three families *Cercopithecidæ*, *Simiidæ*, and *Hominidæ*, the number of the cheek-teeth is always $Pm. \frac{2}{2}$, $M. \frac{3}{3}$, and the crowns of the true molars are either transversely ridged or simply tubercular. The nostrils are straight, and placed close together, and their septum is narrow. In all except *Colobus*, where it is absent, the pollex is opposable to the other digits. The tail is never prehensile, and may be wanting; while cheek-pouches and ischial callosities are often present. With the exception of one species, which occurs at Gibraltar, all the existing *Cercopithecidæ* and *Simiidæ* are confined to Asia and Africa.

FAMILY CERCOPITHECIDÆ.—In this family, which includes most of those Old World genera commonly termed Monkeys and Baboons, the tubercles of the true molars are developed into a pair of imperfect transverse ridges, and the third lower true molar has a hind lobe or talon. It has been stated that the genus *Colobus* occurs in the Miocene of Bavaria, but the specimen on which this determination was made really belongs to the Artiodactylate genus *Cebochœrus*. The somewhat widely spread genus *Macacus* is represented in the Pliocene Siwaliks of India, and also in the Upper Pliocene of the Continent and the Pleistocene of India; one of these continental species having probably been described under the name of *Aulax-*

Fig. 1352.—Left lateral view of the skull of *Cynocephalus ursinus;* Recent. Africa. Reduced.

inus. The Asiatic genus *Semnopithecus* is known by remains of existing species in the Indian Pleistocene, and by extinct forms in the Siwaliks of the same country, and also in the Lower Pliocene of France and Italy. *Mesopithecus*, from the Lower Pliocene of Greece and Hungary, is an extinct genus allied in cranial characters to *Semnopithecus*, but in the structure of the limbs approximating to *Macacus*. The genus *Cynocephalus*, now confined to Africa, and characterised by the long and projecting facial region and the nearly vertical position of the orbits (fig. 1352), is found fossil in the Pliocene Siwaliks of India, and in the Pleistocene of Southern India and Algeria; and thus indicates the intimate relations of the Indian and African faunas. *Oreopithecus*, from the Middle Miocene of Italy, was probably allied to the preceding genus, but only an immature mandible is known.

FAMILY SIMIIDÆ.—In the *Simiidæ*, which includes the Gibbons, Orangs, Chimpanzees, and Gorillas, the tubercles of the cheek-teeth (fig. 1353) are low and blunt, and the angles of their crowns are more or less rounded off, and the third lower true molar has no hind talon. The canines are large, and the hallux is opposable. The Gibbons are represented in a fossil state in the Pleistocene of Borneo by a species of *Hylobates*, and by another from the Middle Miocene of France which may be included in the same genus, although separated by some under the name of *Pliopithecus*. *Dryopithecus*, from the Middle Miocene of France and the Lower Miocene of Hessen-Darmstadt, was a large Ape of the size of the Chimpanzee, but with teeth resembling those of the Gorilla. Lastly, the Pliocene Siwaliks of India have yielded a species of *Anthropopithecus* (*Troglodytes*) apparently closely allied to the existing African Chimpanzee; while there are also indications in the same deposits of a species of the Malayan genus *Simia* (Orang). A skull of the existing species of *Simia* is shown in woodcut, fig. 1354.

Fig. 1353.—Palatal aspect of the mandible of *Hylobates antiquus*; from the Middle Miocene of France.

FAMILY HOMINIDÆ.—The last and highest family of the class comprises only Man (*Homo*), and requires but little notice in this work. It may, however, be observed that the teeth form a nearly even horse-shoe-shaped series, without any diastema or marked increase in the size of the canine, and are thus in striking contrast to those of the *Simiidæ* (compare A and B in fig. 1354); although their number and structure are identical. The skull is also remarkable for the great relative size of the cranial, and the shortness of the facial portion.

Man has certainly existed throughout the Pleistocene period, and there is also evidence of his presence at the epoch of the St Prest beds of the south of France, which are equivalent to the Norfolk Forest-bed, and are referred by some authorities to the base of the Pleistocene, and by others to the top of the Pliocene. Somewhat doubtful evidence of his existence in the true Pliocene of Italy has

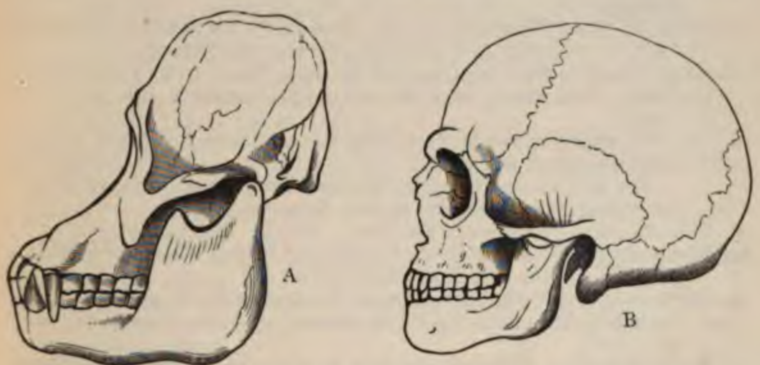

Fig. 1354.—Left lateral view of the skull of (A) the Orang (*Simia*) and (B) a European. Reduced.

been brought forward; and it has been asserted that a skull found in Calaveras county, in the United States, is from Pliocene beds. In the latter instance, however, some authorities doubt whether the skull in question was really obtained from these beds, while others consider that the beds themselves are not earlier than the Pleistocene. Far stronger proofs than those hitherto brought forward must be forthcoming before the alleged existence of Man in the Middle Miocene of France can be accepted. The evidences of his existence in the Recent period belong rather to the domain of the archæologist and ethnologist than to that of the palæontologist.

In conclusion, it may be mentioned that Professor Cope regards the *Hominidæ* as having originated independently of the other Anthropoidea from a Lemuroid stock; but much more conclusive evidence than that yet adduced is necessary to support this view.

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52. POULTON (E. B.)—"The True Teeth and the Horny Plates of *Orni-*

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57. —— "Weitere Beiträge zur Beurtheilung der Pferde der Quaternär-Epoche." 'Abh. Schweiz. pal. Ges.,' vol. ii. (1875).
58. SCHLOSSER (M.)—"Beiträge zur Kenntniss der Stammesgeschicte der Hufthiere, &c." 'Morphol. Jahrbuch,' vol. xii. (1886).
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65. VACEK (M.)—"Ueber Österreichischen Mastodonten, &c." 'Abh. k. k. geol. Reichs.,' vol. vii. (1877).
66. VAN BENEDEN (P. J.)—Various memoirs on the Fossil Cetacea of Belgium, published in the 'Bull. Ac. R. Belgique' and the 'Ann. Mus. R. Hist. Nat. Belgique.'
67. WEITHOFER (K. A.)—"Beiträge zur Kenntniss der Fauna von Pikermi, bei Athen." 'Beiträg. z. Paléontologie Oesterr-Ungar.,' vol. v. (1888).
68. —— "Die fossilen Hyänen des Arno-thaler in Toskana." 'Denkschr. k. Akad. Wien.,' vol. lv. (1889).

It should be mentioned that neither the above nor the preceding lists of memoirs make any approach to a complete bibliography of their respective subjects. They are merely intended to indicate to the student the sources where he will most readily obtain information, and in many cases important memoirs of an early date are not mentioned, since they are quoted in those given in the lists.

PART IV.

PALÆOBOTANY

BY

H. ALLEYNE NICHOLSON AND R. LYDEKKER

PART IV.

CHAPTER LXIV.

CLASSIFICATION AND GENERAL SUCCESSION OF PLANTS IN TIME.

THE department of Palæontology which deals with the relations of Plants to time is usually spoken of under the name of Palæobotany or Palæophytology, and is one of wide extent and great complexity. To render adequate justice to the vast body of knowledge which has been accumulated as to the past history of plants, an amount of space much exceeding that available in the present work would be required. Moreover, the subject is one which cannot be thoroughly dealt with except by a specialist, and which, in itself, is of less importance to the general geological student than is Palæozoology. For these reasons, nothing more will be attempted here than to give an extremely brief and entirely general sketch of the past distribution and succession of the chief types of plant-life; the extinct groups being treated with somewhat greater detail than those now in existence. In most cases, however, no description of the characteristic structures of the different groups can be given; nor is it possible to introduce so much as a sketch of the general morphology of plants. For such the student must be referred to works devoted to structural Botany, to which he must also look for the meaning of such technical terms as are here made use of.

CLASSIFICATION.

As regards the classification of Plants, the following table shows the leading groups into which the existing members of the Vegetable Kingdom are divided :—

KINGDOM VEGETABILIA.

"Cryptogams," or Non-Flowering Plants.

SUB-KINGDOM A.—THALLOPHYTA.

SERIES I.—ALGÆ.

CLASS 1. DIATOMACEÆ . . .	Diatoms.
,, 2. PHYCOCHROMOPHYCÆ	Desmids.
,, 3. FUCACEÆ	Sea-weeds.
,, 4. CHLOROSPOREÆ . .	*Siphoneæ.*
,, 5. FLORIDEÆ . . .	Red Sea-weeds, Corallines, Nullipores.
,, 6. CHARACEÆ . . .	Charas.

SERIES II.—FUNGI.

This series includes the Lichens (*Lichenes*) and the true Fungi, the la being split into several divisions which need not be inserted here.

SUB-KINGDOM B.—CORMOPHYTA.

SERIES I.—BRYOPHYTA (Anogens).

CLASS 1. MUSCI	Mosses.
,, 2. HEPATICÆ . . .	Liverworts.

SERIES II.—PTERIDOPHYTA (Acrogens).

CLASS 1. FILICACEÆ.	
Order 1. STIPULATÆ.	
a. Ophioglosseæ . . .	Adders'-tongues.
b. Marattiaceæ . . .	Marattia.
Order 2. FILICES . . .	Ferns.
Order 3. RHIZOCARPEÆ . .	Rhizocarps.
CLASS 2. EQUISETACEÆ . . .	Horsetails.
CLASS 3. LYCOPODIACEÆ.	
Order 1. ISOSPOREÆ (*Dichotomæ*).	
a. Lycopodeæ	Lycopods.
b. Psiloteæ	
c. Phylloglosseæ . . .	
Order 2. HETEROSPOREÆ (*Ligulatæ*).	
a. Selaginelleæ . . .	Club-mosses.
b. Isoëteæ	

"Phanerogams," or Flowering Plants.

SERIES III.—PHANEROGAMÆ.

CLASS 1. GYMNOSPERMEÆ.	
Order 1. CYCADACEÆ . .	Cycads.
Order 2. CONIFERÆ . .	Conifers.
Order 3. GNETACEÆ . .	Welwitschia.
CLASS 2. ANGIOSPERMEÆ.	
Subclass 1. MONOCOTYLÆ (Endogens) . . .	Grasses, Palms, Lilies, &c.
,, 2. DICOTYLÆ (Exogens)	Rose, Buttercup, Dandelion,

The above classification is, in the main, the one adopted by I fessor Thistleton Dyer, although a less complex arrangement of

Thallophytes has been adopted. The divisions of the Fungi, as being of no importance to palæontologists in the present state of our knowledge, have likewise been omitted; as, also, have been several of the groups of the Algæ. In older botanical systems, plants, in place of being ranged into the two primary divisions of Thallophytes and Cormophytes, were separated into "Cryptogams" and "Phanerogams," the limits of these old divisions being indicated in the margin of the above table; and it will still be sometimes convenient to employ the former term as a collective name for the non-flowering plants. Similarly, the Cryptogams were formerly divided into Thallogens, Anogens, and Acrogens; and we still very generally meet with the two latter terms (the position of which is indicated in brackets in the table) in geological works, where the expression "Age of Acrogens" has become almost classical. It is, however, very inadvisable to retain for geological purposes a classification abandoned by the more advanced botanists; and we shall therefore adopt the names Bryophytes and Pteridophytes in place of the older Anogens and Acrogens.

The Thallophytes are cellular plants not distinctly differentiated into stem and leaf; the *Algæ* being distinguished from the *Fungi* by the presence of chlorophyll. The Bryophytes, while still wholly cellular, may have distinct stems and leaves; while the Pteridophytes are partly composed of cells and partly of long tubes or vessels, and are thus fitted for the attainment of considerable dimensions. The Phanerogams are like the Pteridophytes in being vascular plants, but differ from all the preceding groups in developing flowers, which in turn produce seeds containing an embryo. The series of the Phanerogams is again divided into the Gymnosperms, with naked seeds not enclosed in fruits, and the Angiosperms, in which true fruits enclose the seeds. This latter group is further divisible into two sections, known, from the number of the seed-leaves, as Monocotyledons and Dicotyledons. In the Monocotyledons the embryo has only a single seed-leaf or cotyledon, and the stems grow from within and show no rings of growth; the name of "Endogens" applied to the group being based on this latter feature. In the Dicotyledons, on the other hand, the embryo has two seed-leaves or cotyledons; and the group is sometimes spoken of as that of the "Exogens," since the stems (as in the Gymnosperms also) grow from without, with the formation of distinct rings of growth.

General Succession of Plants in Time.

As in the Animal Kingdom, so among plants there appears to be a general correspondence between relative rank in the scale of organisation and the order of appearance in time. Thus, as Sir William

Dawson observes, "the oldest plants that we as yet certainly know are Algæ, and with these there are plants apparently with the structure of Thallophytes, but the habits of trees, which for want of a better name I may call Protogens" [Nematodendreæ]. "Plants akin to the Rhizocarps also appear very early. Next in order we find forests in which gigantic Ferns, Lycopods, and Horsetails predominate, in association with Pines. Succeeding these we have a reign of Gymnosperms; and in later formations we find the higher Phanerogams dominant. Thus there is an advance in elevation and complexity along with the advance in geological time, but connected with the remarkable fact that in earlier periods low groups attain to an elevation unexampled in later epochs, when their places are occupied with plants of higher types."[1]

The age of Algæ and Nematophytes corresponds with the earlier portion of the Palæozoic period, while Pteridophytes, with some Gymnosperms, are the dominant forms of the later Palæozoic deposits. The Mesozoic period may be termed the "Age of Gymnosperms," while the Angiosperms assume the leading place in the Tertiary. The floras of the great geological periods, however, shade gradually into one another, and no hard-and-fast lines can be drawn between them. Thus, we have already seen that Gymnosperms make their first appearance in the Upper Palæozoic rocks, these ancient types being the precursors of the characteristically Gymnospermous flora of the Mesozoic period. In a similar manner the Upper Cretaceous flora, by its great development of Angiosperms, is more nearly related to the Tertiary than to the preceding Jurassic flora. Moreover, the evolution of the flora of different regions of the earth by no means advanced *pari passu* with the evolution of the fauna—a striking example of this fact being afforded by the Lower Gondwana beds of India and the equivalent deposits of Australia, in which, reckoning from a European standpoint, we find a full-blown Mesozoic flora coexisting with a Palæozoic fauna.

Taking a brief historical retrospect of the distribution of plants in time, we have no direct evidence of the existence of vegetable life during the period represented by the Archæan rocks. There is, however, a strong probability in favour of Sir William Dawson's view that the extensive accumulations of graphite associated with the Laurentian limestones of Canada are really of the nature of metamorphosed vegetable matter, or that they have been derived in the first instance from plants. In deposits of Cambrian age most of the supposed remains of plants belong to the obscure and difficult group of fossils commonly spoken of as "Fucoids," and supposed to be referable to the Sea-weeds. So far as the "Fucoids"

[1] Some slight verbal alterations have been made in this quotation.

of the Cambrian rocks are concerned, there is every probability that we have to deal entirely with the tracks and trails of marine animals, or with impressions of a purely inorganic character. Thus, the Cambrian fossils referred to such genera as *Cruziana* and *Bilobites* are most probably the tracks of Annelides, or the filled-up burrows of Crustaceans. The fossils from the Cambrian rocks of Sweden described under the name of *Eophyton*, and at one time supposed to be the remains of land-plants, are almost certainly not of a vegetable nature. As previously pointed out (p. 209), strong evidence has been brought forward by Nathorst in favour of the view that the striated markings of *Eophyton* are really produced by the trailing of the tentacles of Jelly-fishes over the surface of soft sediment. Lastly, the so-called *Oldhamia* of the Cambrian rocks (p. 205) has been regarded as an Alga, but it may have been produced by animal agency, or it may be wholly inorganic.

From strata of Ordovician age many supposed plants have been

Fig. 1355.—*Licrophycus Ottawaensis*, a supposed "Fucoid" from the Trenton Limestone (Ordovician) of Canada. (After Billings.)

described, and the great majority of these have been referred to the *Algæ*, and have been regarded as the remains of Sea-weeds. Most of these so-called "Fucoids" are wholly destitute of carbon, and are almost certainly not of a vegetable nature. Many of these supposed Sea-weeds—such as those referred to the genera *Palæochorda* and *Crossopodia* (the *Crossochorda* of Schimper)—present themselves as simple, often sinuous or convoluted, raised markings on the surface of muddy or arenaceous sediments. Such markings, as specially insisted on by Nathorst, always occur in demi-relief on the *under* surfaces of the beds in which they are found; and this fact would strongly support the view that they are really the *casts* of the trails of marine animals such as Worms or Molluscs, such trails presenting themselves as depressed impressions on the *upper* surfaces of the strata. Raised impressions on the under sides of the strata, but branched, are not uncommon, and upon these have been founded such genera as *Licrophycus* (fig. 1355). These curious fossils may be regarded as probably of the nature of filled-up worm-burrows, rather than as mere surface-trails.

On the other hand, some of the so-called "Fucoids" of the Ordovician, as also of the Silurian rocks, appear to be truly the

Fig. 1356.—*Buthotrephis gracilis*, Hall; a "Fucoid" from the Trenton Limestone (Ordovician) of Ottawa. (Original.)

remains of marine *Algæ*. This is the case, for example, with some of the fossils which have been referred to the genus *Buthotrephis* of Hall. The types in question (fig. 1356) present themselves as compressed, branching impressions, sometimes showing leaf-like extremities, and occasionally distinctly carbonaceous.

In addition to *Algæ*, the Ordovician rocks have yielded a few unquestionable plant-remains which are regarded by Dawson as probably having been of a higher grade. Thus, the *Protannularia* of the Arenig rocks of Britain, and the *Sphenothallus* of the Cincinnati group of North America, are provisionally referred to the Rhizocarps; while the *Protostigma* of the latter formation is looked upon as possibly allied to the Lycopods.

In the Silurian rocks we meet with various Sea-weeds of an apparently unquestionable character, and along with these are found the remains of plants of a higher type. The most abundant of these belong to the genus *Psilophyton*, regarded by Dawson as forming a connecting link between the Rhizocarps and the Lycopods. The *Glyptodendron* of the Clinton beds may perhaps be related to *Lepidodendron*, but the supposed Silurian fern, described under the name of *Eopteris*, is not truly organic. Lastly, in the Silurian rocks are found the first traces of the singular tree-like plants originally described by Dawson under the name of *Prototaxites*, but now termed *Nematophyton*. The characters of this will be briefly noted immediately; but it may be mentioned here that the curious spore-like bodies, which have been described from the Silurian rocks under the name of *Pachytheca*, are regarded by Dawson as not improbably belonging to this plant.

In the Devonian rocks, as more especially shown by Sir William Dawson, we have evidence of an abundant flora, consisting of both aquatic and terrestrial plants. Of the Devonian fossils which have been referred to the *Algæ*, the most singular is the genus *Spirophyton*, comprising certain broad, spirally twisted impressions, which are very abundant in some of the lower beds of the Devonian series of North America. Similar impressions—often spoken of under the name of "Cauda Galli"—occur in the Lower Carboniferous rocks of Europe; but their real nature is not free from doubt. We may also notice here the highly remarkable tree-like plants for which the genus *Nematophyton* (*Prototaxites*) has been proposed by Dawson, since these cannot at present be definitely referred to any recognised group of existing plants. According to Dawson, the plants in question (fig. 1357) are "trees of large size, with a coaly bark and large spreading roots, having the surface of the stem smooth or irregularly ribbed, but with a nodose or jointed appearance. Internally, they show a tissue of long, cylindrical tubes, traversed by a complex network of horizontal tubes, thinner-walled and of smaller size." The tubes appear to be arranged in concentric zones, but the plant was not truly exogenous, and it is doubtful if a genuine bark was present. The systematic place of *Nematophyton* is uncertain, but the balance of evidence would seem to be in favour of its reference to the Thallophytes, and it is regarded by Dawson as the type of a special group, for which he has proposed the name of *Nematodendreæ*. The same authority is of opinion that the minute globular bodies to which the name of *Pachytheca* has been given,

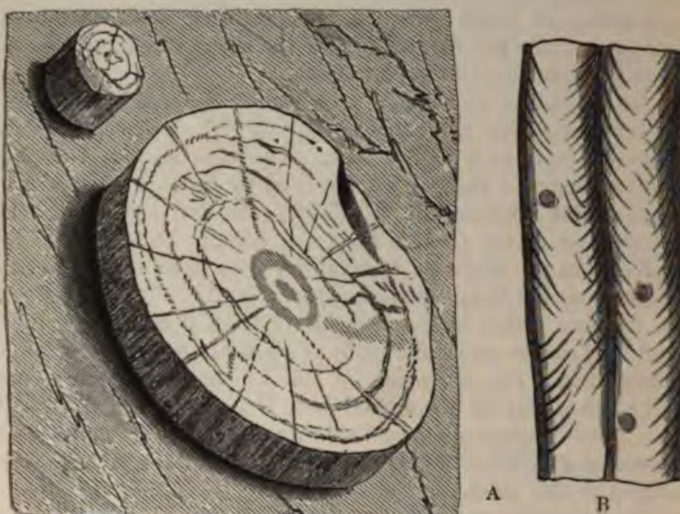

Fig. 1357.—A, Trunk of *Nematophyton* (*Prototaxites*) *Logani*, 18 inches in diameter, as seen in the cliff near L'Anse Brehaut, Gaspé; B, Two of the tubular cells forming the tissue of the stem, highly magnified. Lower Devonian, Canada. (After Dawson.)

may perhaps have been the fruit of *Nematophyton*. As previously noted, the genus occurs also in the Silurian rocks.

Coming to higher plants, the Rhizocarps are represented in the Devonian flora by such types as *Sphenophyllum* and *Psilophyton*, the latter showing affinities with the Lycopods. Moreover, some of the Devonian shales of North America are crowded with minute globular thick-walled bodies (fig. 1358), of a diameter of one-hundredth of an inch or more, which Dawson regards as being probably of the nature of the "macrospores" of plants allied to the Rhizocarps. These were originally described under the name of *Sporangites Huronensis*, but they are now referred by Dawson to the provisional genus *Protosalvinia*. Similar bodies have been shown to occur, often in vast numbers, in shales of Carboniferous age in both North America and Europe, and even some coals appear to be largely made up of structures of a similar nature.

Of still higher groups of plants, the Devonian rocks have yielded the remains of *Lepidodendron* and *Sigillaria*, representing the Lycopods, and of early types of Calamites, representing the Horsetails; while true Ferns, some of which attain considerable dimensions, are in comparative abundance. Lastly, the Gymnosperms are ιted by the woody trunks of Conifers (*Dadoxylon*).

Carboniferous deposits are remarkable for the richness of ntained flora, as also for the extensive development of beds ıble coal. The predominant plants of this period belong to ups of the Pteridophytes and Gymnosperms. The former ·esented by types belonging Rhizocarps, the Ferns, the ds, and the *Equisetaceæ;* in many cases the Carıus plants referred to these exhibit quite peculiar charand their precise affinities always clear. The Rhizoe represented by the ancient *Sphenophyllum* and by the ıores of *Protosalvinia*. The ımetimes occur in vast numthe shales of the Carbonperiod, and occasionally play rtant part in the formation though this must be re-

Fig. 1358.—A slice of shale from the Devonian rocks of Kettle Point, Lake Huron, showing the "macrospores" of *Protosalvinia*, magnified. (Original.)

as exceptional. The *Lycopodiaceæ* are represented by the *ycopodites*, but the most remarkable members of this series oniferous times are the tree-like Lepidodendroids (*Lepido-* &c.) The great group of the Sigillarioids (*Sigillaria*, &c.), comprising comparatively gigantic plants, is also usually l as belonging to the series of the Lycopods, and is highly ristic of the Carboniferous deposits. The *Equisetaceæ*, re largely represented in Carboniferous times by the ree and widely distributed group of the Calamites. Lastly, ·boniferous rocks have yielded the remains of a large of true Ferns, which, in most essential respects, are similar xisting types of the group.

ıquestionable Angiosperms have hitherto been detected in Carboniferous age, but the Gymnosperms are represented us Conifers (*Dadoxylon*, *Araucarioxylon*, and *Pinites*).

ıniversally admitted that coal is fossilised vegetable matter, and ;, in general, the vegetation which formed the coal grew where seam is now found. The problem of the precise mode in which seams of the Coal-measures were formed is largely a geological need not be discussed here. It is sufficient to say here that he result of the bituminisation of vegetable tissues of different fferent coal-seams, or different portions of a single seam, being like in their precise structure or mode of formation. According searches of Sir William Dawson, the microscopic examination of coal by means of thin sections shows that the "mineral charcoal" of an ordinary bituminous coal is woody tissue and fibres of bark. The coarser and more laminated portions of the coal are made up of "a confused mass of fragments of vegetable matter belonging to various descriptions of plants." The shining and brilliant layers of coal represent the bark of Sigillarioids or Lepidodendroids preserved in a flattened condition. Certain coals, or parts of certain coals may, further, be extensively composed of the macrospores or microspores of various Carboniferous Cryptogams; but it does not appear that coals are generally made up of such spores for any considerable portion of their mass. Lastly, the microscopical structure and chemical composition of the "cannel-coals," would show that these are "of the nature of the fine vegetable mud which accumulates in the ponds and shallow lakes of modern swamps."

The flora of the Permian period is, on the whole, nearly related to that of the Carboniferous. The Sigillarioids appear now to have become extinct, but the Lepidodendroids seem to have survived into the earlier portion of the Permian period, while the Calamites are represented by the genus *Arthropitys*, and die out at this stage. No undoubted Permian Angiosperms are known, but Conifers are tolerably abundant. Of the latter the genus *Voltzia*, which survives into the Trias, is an old type of the *Taxodineæ;* while *Walchia* connects the Yews with the Araucarias; and the genus *Ullmania* is of interest as producing true cones.

As regards the Mesozoic period, the predominant forms of plant-life in the Triassic, Jurassic, and Lower Cretaceous rocks are Cycads and Conifers; and the name of "Age of Cycads" has sometimes been given to the Mesozoic period, as regarded from a botanical point of view. Ferns, however, occur abundantly in the earlier Mesozoic deposits (Triassic and Jurassic rocks), and true *Equisetæ* make their appearance in the Upper Trias. The first unquestionable remains of Monocotyledonous Angiosperms present themselves in the Mesozoic period, the *Podocarya* and *Kaidacarpum* of the Jurassic rocks appearing to be referable to the Screw-pines (*Pandanaceæ*). True Palms do not appear till the Middle Cretaceous period is reached, but a few remains of Dicotyledonous Angiosperms have been detected in the Lower Cretaceous deposits of Greenland.

While the Lower Cretaceous rocks must be associated botanically with the Jurassic and Triassic, the Upper Cretaceous deposits, on the other hand, are characterised by a flora similar to that of the Tertiary period. From the point of view of the palæobotanist, therefore, the line of division between the Mesozoic and Kainozoic epochs falls to be drawn in the middle of the Cretaceous system. With the coming in of the Upper Cretaceous period, in both the Old and New Worlds, a remarkable change takes place in the characters of the plant-life of the land, the Cycads now assuming a position of comparative insignificance, while the Dicotyledonous Angiosperms undergo a great development and become the dominant forms.

Not only are the ordinary Exogens now the leading forms of plant-life, but many of the Upper Cretaceous types belong to genera now existing. We may therefore regard the Upper Cretaceous period as marking "the advent of the modern flora of the temperate regions of the earth" (Dawson). It follows that the Tertiary floras, regarded generally, more or less closely resemble those now in existence, this resemblance being especially shown in the fact that the predominant forms of plant-life are now the Angiosperms, and, more particularly, the Dicotyledons.

CHAPTER LXV.

ALGÆ AND FUNGI.

THE plants included in the great series of the *Thallophyta* are separable into the two primary divisions of the *Algæ* and *Fungi*, and are characterised by the fact that they are composed of cells, without true vascular tissue. They may be either unicellular or multicellular, the organism in the latter case forming an expansion or "thallus" which is not differentiated into stem, leaf, and root. In the lower Thallophytes reproduction may be wholly non-sexual; but in the higher forms sexual reproduction takes place, the result being the formation of a spore, or a group of spores, or a fructification within which spores are produced.

SERIES I. ALGÆ.—The group of the *Algæ* includes unicellular or multicellular Thallophytes in which chlorophyll is developed in larger or smaller quantity. They vary extremely in form, and are for the most part inhabitants of water, both fresh and salt. The *Algæ* may be divided into the following six classes, viz.:—

Class	I.	Diatomaceæ	Diatoms.
,,	II.	Phycochromophycæ	Desmids.
,,	III.	Fucaceæ	Brown Sea-weeds.
,,	IV.	Chlorosporeæ	*Cymopolia*, &c.
,,	V.	Florideæ	Red Sea-weeds, Nullipores.
,,	VI.	Characeæ	*Chara* and *Nitella*.

As regards the general distribution of the *Algæ* in time, many forms are quite incapable of preservation as fossils, while others can only be preserved under specially favourable circumstances. In certain groups, however, the organism may secrete a siliceous envelope, or its tissues may undergo calcification, while others become encrusted with carbonate of lime. Such forms readily admit of petrifaction, and unquestionable remains of these occur in the fossil state. Apart from these undoubted fossil *Algæ*, numerous markings nd impressions in rocks of all ages, and especially in the older :rata of the earth's crust, have been regarded by palæontologists as ie remains of Sea-weeds. The characters and probable mode of rigin of many of these so-called "Fucoids" have been already dis- ussed in a general way (see p. 483 and pp. 1481, 1482). It is suffi- ient to say here that many of the fossils in question may be safely :garded as not belonging to the vegetable kingdom, but as being ither of the nature of the tracks and trails of Worms or Molluscs, or ie burrows of Annelides or Crustaceans; while others are of purely iorganic origin. Some "Fucoids," on the other hand, such, for xample, as some of the Tertiary or Secondary fossils referred to *'hondrites*, may really be the remains of Sea-weeds. Even, however, i cases where there is a reasonable probability that these so-called Fucoids" are really Sea-weeds, it is nevertheless impossible to de- :rmine definitely to what group of the *Algæ* they belong, since the uctification of the plant is not known. In the following brief :count, therefore, of the past history of the *Algæ*, only those groups ill be treated of which are of palæontological importance.

CLASS I. DIATOMACEÆ.—The Diatoms are unicellular *Algæ*, in hich the cell-wall is hardened by the deposition of silica so as to ive rise to a glassy case or "frustule," composed of two halves hich fit into one another, and which are often minutely sculptured ith lines or dots (fig. 1359). The cells may be solitary, or they

Fig. 1359.—Types of Diatoms, greatly magnified. *a*, *Navicula*, from the Kieselguhr of 'anzenbad; *b*, *Actinoptychus*, from Richmond, Virginia; *c*, *Pinnularia*, from Santafiora, aly; *d*, *Achnanthes*, from Degernfors, Sweden; *e*, *Diatoma*, recent; *f*, *Triceratium*, from e guano of Saldanha Bay, Africa.

ay be organically united in rows. Reproduction takes place by ie longitudinal fission of the cell, each of the daughter-cells carry- g off half of the original cell-wall, and producing the missing half resh, the two halves of the siliceous case being thus of different zes.

The existing forms of the Diatoms are exceedingly numerous, and ive an extraordinarily wide distribution. A few live in moist tuations, but the majority are truly aquatic, inhabiting fresh, brack- h, or salt waters, peculiar types usually being confined to a special ibitat. By the accumulation of their flinty envelopes the Diatoms give rise, both in the sea and in fresh waters, to very extensive deposits, the general nature of which is that of a fine siliceous mud, sometimes arranged in thin laminæ. Of this nature are the deposits known as "Kieselguhr," "Bergmehl," "Tripoli," and "Polir-schiefer," or, simply, as "Diatomaceous Earths." Such deposits may cover wide areas, and may attain a very considerable thickness; and, under an erroneous idea as to their true nature, they have been sometimes spoken of as "Infusorial Earths."

As regards their distribution in time, the cases of Diatoms have been stated to occur in the ashes of the coal of the Coal-measures, but this observation has not been supported by subsequent investigations. In the Middle and Upper Trias whole strata are sometimes largely made up of elongated, parallel-sided, siliceous tubes, with flattened sides and rounded ends, which have been described under the generic name of *Bactrynium*, and which may possibly be Diatoms. If this be their real nature, they are comparatively gigantic members of the class, as they attain a length of from two to four millimetres. Leaving these problematical fossils out of sight, undoubted Diatoms occur in the Upper Chalk, though only a few forms are known. The regular "Diatomaceous Earths" are all of Tertiary or Post-Tertiary age; and among the best known deposits of this epoch may be mentioned the numerous beds of "Kieselguhr" which occupy the sites of ancient lakes in various regions in the northern hemisphere, the "Richmond Earth" of Virginia, the "Tripoli" of Oran in Africa, and Bilin in Bohemia, and the laminated "Polir-schiefer" of Cassel.

CLASS II. PHYCOCHROMOPHYCÆ.—The *Algæ* included in this class are unicellular or multicellular, usually bluish-green in colour, and inhabit water or live in moist places on land. Reproduction takes place by cell-division, or by the formation of asexually-produced cells ("gonidia"). The integument is not hardened by the deposition of silica within it. In this class are included numerous widely distributed forms of the *Algæ*, such as the *Oscillariæ*, the Nostocs, and the Desmids. Owing to the soft nature of their outer covering, no undoubted remains of this class of *Algæ* have been detected in the fossil condition; but remains of *Nostoc* are said to occur in strata of Tertiary age, and the curious spherical and spined bodies which are known as *Xanthidia*, and which are sometimes recognisable under the microscope in thin sections of flint or chert, have been supposed to be the spores of Desmids.

CLASS III. FUCACEÆ.—This class includes the common brown Sea-weeds, and comprises forms which are often of considerable size and of various shape. The thallus is often foliaceous and much branched, or may be more or less filamentous. The reproductive organs are developed in special cavities or "conceptacles." The integument is not hardened by the deposition of lime or flint. Certain Tertiary fossils have been described by palæobotanists as belonging to this group of Sea-weeds, but the nature of many of these is very doubtful.

Class IV. Chlorosporeæ.—This class includes a number of green or olive-coloured Algæ, which live in the sea or in fresh waters, and which reproduce themselves by cell-division or by the development of spores in special cavities, while swarm-spores occasionally exist. The only group of this class which attains sufficient palæontological importance to require special notice is that of the *Siphoneæ verticillatæ*. This family includes green-coloured marine Algæ, in which the thallus consists of a single cell, which may or may not be hardened by the deposition of carbonate of lime in its wall. The single cell which constitutes the entire plant may be of gigantic size, comparatively speaking, and may be simple or branched. At its base the cell sends out root-like prolongations, by means of which it is attached to foreign bodies; while its ascending portion gives origin to whorls of lateral tubular processes. Reproduction takes place by the development of swarm-spores in special cavities or chambers. The few living forms of this family (*Cymopolia*, *Neomeris*, *Acetabularia*, &c.) are inhabitants of warm seas; and with these must be associated an extensive series of fossil types, which have been commonly regarded as referable to the *Foraminifera* or the Corals, and the real nature of which was first demonstrated by Munier-Chalmas.

As above pointed out, the thallus of the *Siphoneæ verticillatæ* may be simple or dichotomously branched, and consists of a single axial cell, which is fixed to foreign bodies by root-like basal extensions. The unicellular, often divided, axis gives out at intervals whorls of short tubular processes (fig. 1360, B), the point of origin of each whorl being commonly marked by a constriction of the stem. In some cases (*e.g.*, in *Ovulites* and *Diplopora*) the primary whorled processes do not subdivide; but in others (*e.g.*, in *Cymopolia*) the primary offshoots (fig. 1360, C, *c*) divide again into secondary processes, some of which (*b*) are sterile, while others (*a*) are connected with reproduction. The sterile offshoots terminate in free extremities which are often dilated and club-shaped, and by their apposition give rise to a porous superficial layer. The fertile offshoots, on the other hand, constitute spherical sporangia (*a*), which are wider than the sterile processes, and are at the same time supported upon shorter stalks.

In many forms, both the axis and the verticillate processes derived from it secrete a thick calcareous crust. Where the lateral whorled offshoots are simple (as in *Diplopora*), the calcareous crust has the form of a simple thickened cylinder, traversed by transverse tubes, which correspond with the lateral processes, and open by pores upon the surface. On the other hand, where there are two orders of lateral offshoots (as in *Cymopolia*), a double calcareous cylinder is produced, the inner one corresponding with the axis and the primary whorled processes, while the outer one is formed by the confluent clavate ends of the secondary processes. The spherical sporangia may also become calcified, and may present themselves as rounded

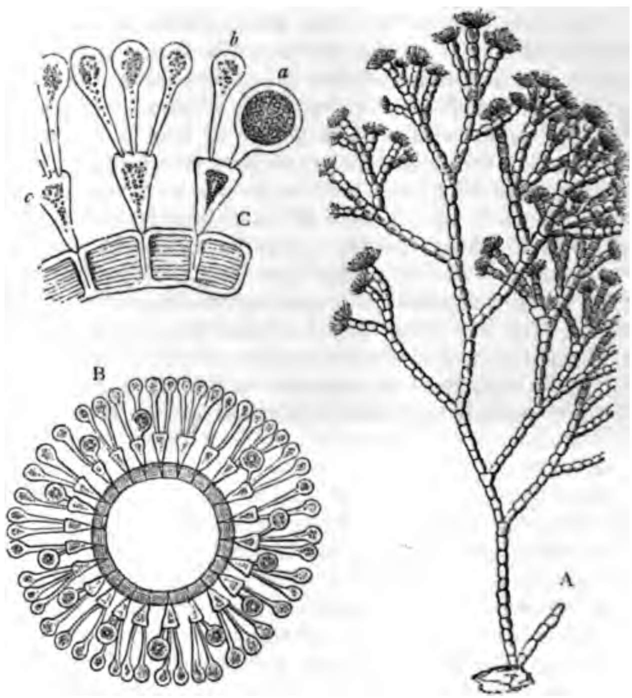

Fig. 1360.—*Cymopolia barbata* (=*C. rosarium*), from the Canary Islands (Recent). A, A specimen of the natural size, showing the divided thallus; B, Transverse section through a segment of the stem, showing a whorl of lateral processes, of which some are sterile and some fertile; C, Part of the same whorl enlarged still further, showing the primary lateral processes (c), giving off sterile offshoots (*b*), and spherical sporangia (*a*). (After Schimper and Zittel.)

cavities in the skeleton. Finally, the cylindrical skeleton may be composed of annular segments or may be undivided, according as the axial cell is, or is not, constricted at intervals. In the former case, the segments are often readily capable of separation, and in fossil examples often present themselves as detached calcareous rings.

When the calcareous skeleton is all that is open to our inspection, as in fossil specimens, the transverse canals with their superficial pores, corresponding with the lateral whorled processes, may very readily be mistaken for the tubes of polypes or the chambers of polythalamous Foraminifera; and the fossil forms of the family were until recently regarded as referable to the animal kingdom. It was first shown by Munier-Chalmas ("Comptes rendus," tom. lxxxv. p. 814, 1877) that the supposed *Foraminifera* described under the names of *Dactylopora* and *Ovulites* were really referable to the *Algæ*, and that, along with many other types, they belonged to the group of the *Siphoneæ verticillatæ*. Palæontologists, in fact, are now acquainted with an extensive series of fossil forms of this remarkable family of *Algæ*, which not uncommonly give rise to very considerable rock-masses, and thus become of geological importance. The oldest type of the *Siphoneæ verticillatæ* is apparently the *Cœlotrochium* of the Middle Devonian of the Eifel; though the nature of this fossil is not absolutely certain. The Carboniferous Limestone of England also sometimes contains numbers of small calcareous cylinders, with a porous surface, which are probably referable to this family; but further investigation is needed before this can be positively asserted. It is, also, not impossible that the organism described by De Koninck from the Carboniferous Limestone of Belgium, under the name of *Monticulipora inflata*—which likewise occurs in the same formation in Britain, and sometimes attains a considerable size—may really be a peculiar type of the *Siphoneæ*. Apart from the above, the first undoubted appearance of forms of this family is in the Permian rocks, in which the genus *Gyroporella* is found. It is, however, in the Upper Trias that the maximum development of the *Siphoneæ verticillatæ* takes place, the limestones of this period being often essentially made up of the cylinders of *Gyroporella* and *Diplopora*, as occurs, for example, in the Bavarian and Tyrolese Alps. Various forms of the group also occur in the Jurassic and Cretaceous rocks, while there are numerous Tertiary types; but the family is at the present day represented by but a few species, and the range of these is very limited.

Among the more important types of the *Siphoneæ verticillatæ* which occur in the fossil state are species belonging to the genera *Cymopolia*, *Larvaria*, *Dactylopora*, *Gyroporella* (with *Diplopora*), and *Uteria*. In *Cymopolia* (fig. 1360) the thallus is branched, and is covered with a hollow calcareous crust, the surface of which shows close-set pores. The lateral processes, sterile and fertile, are developed in whorls, separated by vacant nodes. A living species of this genus is found in the seas of the Canary Islands and West Indies; while the calcareous cylinders of fossil forms occur not uncommonly in the Eocene Tertiary, and were originally described under the name of *Dactylopora*. The genus *Larvaria* is nearly allied to *Cymopolia*, and likewise includes forms—such as *L. eruca* (fig. 1361, A) and

L. annulus (fig. 1361, B)—which were originally described under the name of *Dactylopora*. Existing forms of *Larvaria* are known, and fossil types occur commonly in the Eocene Tertiary, often in the form of separate segments of the calcareous cylinder. *Dactylopora*, as now restricted, includes Eocene and Miocene types, and is also closely allied to *Cymopolia*. *Gyroporella* (including *Diplopora*) comprises types in which the skeleton has the form of a short calcareous cylinder (figs. 1361, E–G), from one to six millimetres in diameter, with two or more rows of pores on each segment of the stem. This genus begins in the Permian rocks, and is so enormously

Fig. 1361.—A, *Larvaria* (*Dactylopora*) *eruca* (recent) magnified 30 diameters, and viewed from the inner face; B, *Larvaria* (*Dactylopora*) *annulus*, from the Eocene Tertiary, magnified 40 diameters, viewed in profile, and showing two superimposed rings; C, The same viewed from above and similarly magnified; D, Part of the cylinder of *Dactylopora reticulata* (Tertiary), viewed in profile, and similarly enlarged; E, Fragment of Muschelkalk, with tubes of *Gyroporella cylindrica*, of the natural size; F, Transverse section of a tube of the same, enlarged 10 diameters; G, Vertical section of the same, enlarged 12 diameters. (Figs. A–D are after Carpenter; figs. E–G are after Gümbel.)

developed in the Trias of Southern Germany and Switzerland as to give rise to massive and widespread beds of limestone. A species of this genus also occurs in great numbers in the Cretaceous series of the Southern Lebanon Mountains. In the genus *Ovulites*, again, the skeleton usually presents itself in the form of a small, ovoid or clavate, calcareous body, enclosing a single chamber, with regularly disposed superficial pores, and often perforated at both poles. Such a body is really a single joint of the stem of the original plant. The species of *Ovulites* are found in deposits of Eocene and Miocene age. Lastly, in the genus *Uteria*, the skeleton consists of branched, cylindrical calcareous stems, which readily separate into their component segments. Each segment is hollow, with smooth or radiately-striate articulating surfaces at its ends; the inner and outer walls being porous, and the space between these being vacant. The detached segments of *Uteria* occur commonly in the Eocene deposits of the Paris basin.

CLASS V. FLORIDEÆ.—This class includes a large number of marine and a few freshwater *Algæ*, which are in general red or violet in colour. The thallus is very variable in form, and is often much branched. Reproduction may be sexual or non-sexual. In the former case fertilisation is effected by means of non-motile antherozoöids, the result being the conversion of the female organ into a receptacle, or "cystocarp," within which spores are formed. Non-sexual reproduction is effected by means of special cells ("tetraspores") developed in parts of the thallus.

With regard to their *distribution in time*, a few types of the ordinary Red Sea-weeds (*Delesseria*, *Sphærococcites*, &c.) have been recognised as occurring in the older Tertiary deposits. With these limited exceptions, all the fossil forms of this class belong to the Corallines and Nullipores (*Corallineæ*), in which the thallus is hardened by the deposition of carbonate of lime. The principal genera of the family of the Corallines are *Corallina*, *Melobesia*, and *Lithothamnion*.

In *Corallina*, the thallus is erect and branched, and is composed of rounded or wedge-shaped calcareous segments, which readily separate from one another. The fructification consists of "cystocarps," which are immersed and have an aperture at their summit. The "Corallines" are exceedingly abundant in existing seas, but little is certainly known of their occurrence in the fossil condition. They are, however, stated to occur in the Eocene beds of the Paris basin.

In *Melobesia* the calcareous thallus is crust-like and foliaceous, and is attached by the whole of its lower surface to foreign bodies. The superficial layer of the stony crust is composed of minute cubical cells, but the deeper cells are elongated. The "cystocarps" are immersed within the thallus, and project above the surface as wart-like tubercles. *Melobesia* has not been clearly recognised in the fossil state, though it is not improbable that it will ultimately be found to occur even in the Palæozoic rocks.

In connection with *Melobesia* a few words may be said about the curious little calcareous bodies known as "coccoliths," since it has been suggested by Carter that these are connected with the reproduction of Algæ belonging to this genus. Coccoliths are excessively minute calcareous bodies, of a discoidal form, which are found in the mud of the deep sea at the present day, often in great numbers. Similar bodies occur abundantly in the White Chalk, and Gümbel has shown that they are present in many limestones, even in those of the older Palæozoic formations. Two distinct forms of coccoliths are known, which have been described by Huxley under the names of "discoliths" and "cyatholiths." The former of these (fig. 1362, *a*) are minute calcareous discs, averaging $\frac{1}{4000}$ to $\frac{1}{5000}$ inch in diameter, provided with a raised rim on one side (*b* and *c*), and having a central corpuscle or nucleus. The

Fig. 1362.—Coccoliths and coccosphere. *a*, A "discolith" seen in front view; *b* and *c*, "Discoliths" viewed edgeways; *d*, "Cyatholith" seen in front view, showing the outer transparent zone, the inner granular zone, and the central corpuscle; *e*, "Cyatholith" seen in profile; *f*, A "coccosphere." All the figures are greatly magnified. (After W. B. Carpenter and Wyville Thomson.)

"cyatholiths" vary from $\frac{1}{1000}$ to $\frac{1}{8000}$ inch in diameter, and when viewed sideways (fig. 1362, *e*) are seen to have the form of a shirt-stud, and to consist of two concavo-convex calcareous discs, of which one is smaller than the other and is united to the concavity of the larger by a short stalk. When viewed in front (*d*), the cyatholith presents itself as an oval or circular body, composed of two concentric zones surrounding an oval central corpuscle, the inner of the two zones being more or less distinctly granular, while the outer one is transparent. Cyatholiths occur in vast numbers in the mud of the deep sea in their detached condition, but they are also found aggregated into spherical masses, which may reach $\frac{1}{150}$ inch in diameter, and are known as "coccospheres" (fig. 1362, *f*). The precise nature of the coccoliths and coccospheres is at present uncertain; but it has been suggested by Carter that the "coccospheres" are connected with the reproduction of species of *Melobesia*.

The only remaining genus of the *Corallineæ* which demands consideration is *Lithothamnion*, under which are included the well-

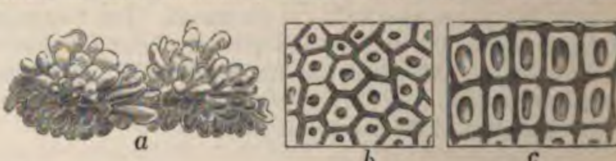

Fig. 1363.—*Lithothamnion ramosissimum*, a "Nullipore," from the "Leitha-Kalk" of the Vienna basin. *a*, Portion of a mass, of the natural size; *b* and *c*, Transverse and vertical sections of the same magnified 320 diameters. (After Gümbel.)

known and widely distributed calcareous *Algæ* which are commonly spoken of as "Nullipores," and which are exclusively marine in 'he thallus of the Nullipores is highly calcareous and of dness, and it may be en- botryoidal, stalactitic, or form (fig. 1363). As re- microscopic structure of ed thallus, the outer layer l of hexagonal or quad- of very small size, while of the interior are oblong The fructification con- "cystocarps," scattered he thallus, and either im- r projecting as tubercles. gards the distribution of s in time, the remains of f *Lithothamnion* are found umbers in various Tertiary s, often giving rise to limestones, such as the Kalk" of Austria (fig. he "Nullipore-limestone" a, and others. Remains *hamnion* are also found in the Cretaceous and Jurassic d they have been said to rocks as old as the Car- s Limestone. The fossil f *Lithothamnion* do not ny marked structural dif- as compared with the ex- es of the genus.

Fig. 1364.—Section of "Leitha-Kalk" (Tertiary) from the neighbourhood of Vienna, showing fragments of Nullipores (*Lithothamnion*), enlarged three times. (Original.)

VI. CHARACEÆ. — This nprises a number of fresh- brackish-water Algæ, of a lour, and remarkable for ateral appendages corres- with leaves. The thallus of a central stem giving ls of leaves at intervals, turn give off secondary The male reproductive s the form of a spherical 1365, *a*), and has been es spoken of as the "glo- The female reproductive "carpogonium"—sometimes spoken of as the "nucule"

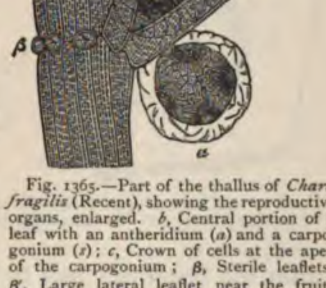

Fig. 1365.—Part of the thallus of *Chara fragilis* (Recent), showing the reproductive organs, enlarged. *b*, Central portion of a leaf with an antheridium (*a*) and a carpogonium (*s*); *c*, Crown of cells at the apex of the carpogonium; *β*, Sterile leaflets; *β′*, Large lateral leaflet near the fruit; *β″*, *β″*, Leaflets attached to the base of the carpogonium. (After Sachs.)

—consists of a large central cell surrounded by a sheath of spirally-twisted cells, and bearing a crown of small teeth at its summit (fig. 1365, *s*).

The recent genus *Nitella* remains permanently soft, and is unknown in the fossil condition. On the other hand, the integument of *Chara* itself becomes hardened by an encrustation of carbonate of lime, and is thus capable of preservation in the fossil state. The fossil forms of the genus *Chara* occur in the Triassic, Jurassic, and Cretaceous formations, and are abundant in parts of the Tertiary series. In some cases (as in the chert of the Purbeck beds) the stems are found; but the fruits or "carpogonia" are more commonly preserved. These have the form of spirally ridged or grooved, ovoid or globular bodies (fig. 1366), and the first type discovered was described by Lamarck under the name of "Gyrogonites." The fossil carpogonia of species of *Chara* are abundantly found in certain freshwater deposits, both of Secondary and of Tertiary age.

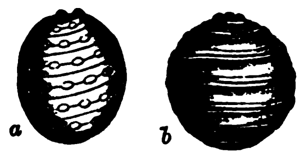

Fig. 1366.—*a*, Carpogonium of *Chara Greslini*, Tertiary, enlarged; *b*, Carpogonium of *Chara Medicaginula* ("Gyrogonites"), from the Eocene beds of the Paris basin, enlarged. (After Schimper and Zittel.)

FUNGI.

The series of the *Fungi*, in which the Lichens are now included, comprises Thallophytes which are closely allied to the *Algæ*, but which are devoid of chlorophyll. Owing to the soft nature of their

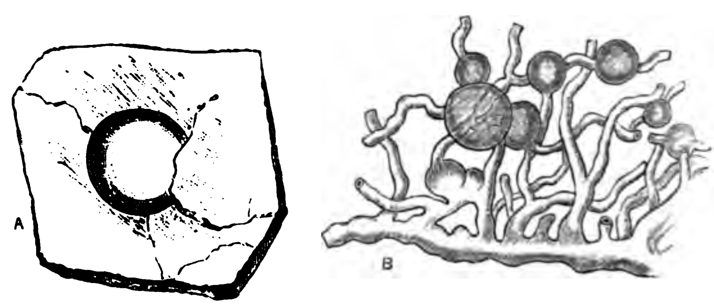

Fig. 1367.—A, A lenticular specimen of *Archagaricon*, of the natural size; B, Slice of the same showing the tubes and vesicles, enlarged. Coal-measures. (After Hancock and Atthey.)

tissues, the *Fungi* can only be preserved in the fossil state under specially favourable conditions. The plants of this series are, therefore, of very small palæontological importance, and may be very briefly dismissed.

Various minute forms of *Fungi* have been recognised as occurring on the leaves of fossil plants, the oldest of these being found on the leaves of Cycads in Triassic deposits. The fossil leaves of Tertiary plants are very commonly attacked by these parasitic plants; and other minute forms have been detected in amber. In other cases, the mycelial tubes of a Fungus have been preserved within the woody stem of a plant of higher grade, or the entire Fungus may have undergone silicification. Thus, the mycelial tubes of a Fungus (*Peronosporites*) have been detected in the tissues of the stems of Carboniferous plants. Messrs Hancock and Atthey have also described, under the name of *Archagaricon*, certain silicified fossils from the Coal-measures of Northumberland, which they regard as referable to the *Fungi*. These remarkable fossils (fig. 1367) present themselves as oval, rounded, lenticular, or irregular bodies, under an inch in length, which appear on microscopic examination to be composed of irregular, ramifying, tubular filaments, terminating in rounded vesicles.

Lichens are almost unknown as fossils, no example of these plants having been detected in any Palæozoic or Mesozoic deposit. A few forms have, however, been recognised in amber, and others have been detected on the bark of fossil trees in lignites of Tertiary age.

CHAPTER LXVI.

SUB-KINGDOM CORMOPHYTA.

SERIES BRYOPHYTA AND PTERIDOPHYTA.

SUB-KINGDOM B. CORMOPHYTA.—This division, which includes all other plants, can only be distinguished as a whole from the Thallophyta by the general presence of leaves, stem, and root; or at least by the opposition of the stem and root. The alternation of generations is more regular than in the Thallophytes; a sexual production of sporophores, and an asexual production of oöphores, following in sequence.

SERIES I. BRYOPHYTA.—The first series includes the Mosses and Liverworts, which are cellular plants, with complete alternation of generations, and without true vascular tissue. The spores, either directly, or by the intervention of a *protonema*, give rise to the sexual generation, or *oöphore*, which forms the main plant, in the female organ (*archegonium*) of which arises the *sporogonium* (*sporophore*) from which the spores are asexually produced. The main plant is therefore a sexual oöphore.

CLASS 1. MUSCI.—In the Mosses the spore produces a large conferva-like protonema, from which the plant (oöphore) arises by lateral branching, and is differentiated into stems and leaves upon which the sexual organs are formed. The class is practically of no palæontological importance, and it will accordingly be unnecessary to notice its divisions. All the fossil forms at present known are of Tertiary age; but from the occurrence of a Jurassic Beetle allied to types which live in moss, it is inferred that the class is really much older. A number of species have been found in amber, most of which appear allied to existing European types; and some also occur in the Miocene of Bonn and the Upper Eocene of Provence, but the absence of fructification renders their generic position uncertain. The genus *Sphagnum*, or Peat-moss, has, however, been definitely determined from the Miocene of Westerwald.

CLASS 2. HEPATICÆ.—The Liverworts differ from the Mosses in the absence of true leaves, and in the bilateral condition of the plant, which has the side exposed to the light differently organised from the concealed one; the oöphore, moreover, generally arises directly from the spore, the protonema, when present, being insignificant. Hair-like growths, representing aborted leaves, are occasionally present on the under side of the plant; and it is fairly certain that Liverworts are to be regarded as degraded forms which have lost the leaves and branches of the Musci. The widely spread existing genus *Marchantia* is represented in the European Eocene and Miocene, and numerous *Jungermanniaceæ* have been found in amber; but beyond this nothing is known of the palæontological history of the class.

SERIES II. PTERIDOPHYTA.—The Pteridophytes are characterised by the great vegetative development of the sporophore, and the tendency to the suppression of that of the oöphore, or sexual generation. Their tissue develops fibro-vascular bundles, and there is a distinct epidermis. There is also a complete alternation of generations, the spore developing a sexual *prothallium* (oöphore), from the archegonium, or female organ, of which is sexually produced the main plant or sporophore, which in its turn asexually develops spores of one or two kinds in organs termed *sporangia*; the latter being generally borne either on ordinary or specialised leaves, but in some cases on the stem. It will be apparent from this that the main plant is an asexual sporophore corresponding physiologically with the sporogonium of the Bryophytes, while the sexual prothallium represents the leaf-bearing plant of the latter.

The Pteridophytes—equivalent to the Acrogens of older writers—are of extreme importance to the palæontologist, since they contain several groups of entirely extinct types; and in the earlier epoch of the earth's history, when they were not brought into extensive competition with the Phanerogams, they attained an importance, both in the number of types and in the large size attained by many of their representatives, which entitles them to be considered the dominant forms of the Palæozoic epoch.

CLASS I. FILICACEÆ.—The Ferns and their allies have the leaves highly developed, and frequently much branched in a pinnate manner; the sporangia being numerous, and borne either upon the ordinary or specially modified leaves, on which they are usually arranged in groups or *sori*. The class may be divided into three orders.

The leaves of Filicaceæ may be either simple, as in *Glossopteris* (fig. 1376), or pinnate. Among pinnate types the pinnation may be simple, as in *Neuropteridium* (fig. 1373), when the leaflets or pinnules are arranged upon a single shaft; or bipinnate (*Neuropteris*, fig. 1371), when secondary shafts are developed; tripinnate, as in *Sphenopteris* (fig. 1369), when tertiary shafts occur; or multipinnate. The coverings of the sori are termed *indusia;* and when the stem is creeping it is known as a *rhizome.*

ORDER 1. STIPULATÆ.—This order now contains only the two families *Ophioglossaceæ* and *Marattiaceæ*, characterised by the presence of stipules at the base of the petioles of the leaves. Of the former *Ophioglossum* (Adder's-tongue), in which the sporangia are embedded in the tissue of the partly sterile and partly fertile leaves, occurs in the Middle Eocene of Monte Bolca; while it is probable that *Chiropteris*, of the Keuper of Würtemberg, is not really separable. In the second family, where the sporangia are external, as in the Ferns, the existing genus *Marattia* occurs in the Rhætic and Lias of the Continent. *Danæites* and *Danæopsis*, on the other hand, are extinct types, the former occurring in the Cretaceous of Europe, and the latter in the Keuper, and probably also in the Permian, of the Tyrol, as well as in the Rajmahal stage of the Indian Gondwanas. Finally, the living genus *Danæa* occurs in the Lias of Verona. Several of the fossil forms have been confused with the *Tæniopterideæ*, while Schimper has referred to this family some of the forms noticed under the *Pecopterideæ*. According to Mr Kidston, the *Archæopterideæ* should probably be placed in this order.

ORDER 2. FILICES.—In existing Ferns stipules are wanting; and there is only one kind of spores; so that the sexual stage is not reached till the prothallium.

Existing forms are classified by the nature of their fructification; but since this is generally unknown in the earlier fossil types, we are compelled to classify them by the nature of the pinnation and venation of the leaves, and as these are subject to great variation among allied existing genera, it is evident that this classification is more or less of an artificial nature. It will be convenient to follow Schimper's plan of treating first of those existing families which are known to be represented in a fossil state, and then to notice the forms of which the position is more or less uncertain, but which are provisionally arranged in families.

EXISTING FAMILIES.—In the existing series the family *Osmundaceæ* has the paniculate fructification borne on specialised leaves, which may or may not be like the sterile ones. The type genus *Osmunda*, which is mainly characteristic of warmer regions, although represented in England by the Royal-Fern, occurs fossil in the Cretaceous of Westphalia and Greenland, in the Laramie beds of North America, and in many of the European Tertiaries. An allied form, from the freshwater deposits of Chemnitz, has been named *Asteroclæna*. In the *Schizeaceæ*, which usually have the fructification borne in spikes or panicles on the *laciniæ* of the leaves, the existing tropical genus *Lygodium* occurs in Europe from the Cretaceous to the Miocene, and also in the Laramie beds of the United States. The third family—*Gleicheniaceæ*—has the sessile sporangia borne in naked sori upon the dorsal surface of ordinary leaves, each sporangium having a complete transverse ring, and bursting with a longitudinal slit; while the stem forms a creeping rhizome. The existing tropical genus *Gleichenia* is represented by closely allied forms in the Cretaceous of Greenland, the Rajmahal group of the Indian Gondwanas, and in the Lias of Verona, some of which have been separated as *Gleichenites*. *Didymosorus*, from the Cretaceous of Greenland and Saxony, with two sori on each leaflet, connects the preceding with *Mertensia*. The latter, which has two rows of sori on each leaflet, and is now confined to the southern hemisphere, occurs in the Cretaceous of Greenland and Hungary. The *Hymenophyllaceæ*, or Film-ferns, in which the sessile sori are covered by an indusium, are represented by one species in the Upper Eocene of Provence; while Schimper has referred to the type genus *Hymenophyllum* a Carboniferous fern. It is probable that some of the *Sphenopterideæ* are more or less closely related to this family. The fifth family—*Cyathecaceæ*—which includes the tropical Tree-ferns, is of more palæontological importance; it is characterised by the stalked sporangia, situated in closely packed sori, which may be naked or covered. Of Tree-ferns, in which there is a tall stem, often covered with roots, and crowned with a rosette of leaves, the existing *Alsophila* is represented in the Lower Eocene of Sézanne, which also contains other allied forms. The Carboniferous *Choroniopteris* should perhaps find a place here. Of smaller forms, the genus *Onoclea* (in which Schimper includes *Struthiopteris*) is represented in the Laramie Cretaceous and the Miocene of the United States, as well as in the Eocene of the Isle of Mull, by the existing *O. sensibilis* of North America; thus offering a remarkable instance of the persistence of a specific type. The Mull form was originally described as *Filicites*. The Laramie series also yields an extinct species of this genus. These ferns, like the following, have the sporangia borne on specialised leaves. *Dicksonia*, which is mainly tropical and often tree-like, occurs in the European Keuper, and more abundantly in the Jurassic, and is also found in the Indian Rajmahal beds. Finally, *Thrysopteris*, now known only by a single species from Juan Fernandez, is also very common in the European and Siberian Jurassic (fig. 1368), where it has been described as *Coniopteris* and *Tympanophora*. In addition to the special fertile leaves, a few sori are borne at the base of the ordinary leaves, as shown in the figure.

Lastly, we come to the extensive family *Polypodiaceæ*, which includes the greater number of European ferns, and is divided into several subfamilies. The sporangia are very numerous, and are borne on the underside of usually unmodified leaves; and they split transversely. Of the subfamilies, the *Polypodieæ* are perhaps represented by the typical *Polypodium* in the Miocene of Switzerland; *Chilanthes* occurs in the same deposits; while the widely-spread *Pteris* (Bracken) is found abundantly in the Upper Cretaceous and the Middle and Upper Tertiaries of Europe, and also in the Laramie and Tertiaries of America. *Adiantum* is also equally well represented throughout the European Tertiaries, and if we include in it the so-called *Adiantites*, it ranged down to the Jurassic. In the *Asplenieæ*, *Blechnum* (Hard-fern), distinguished by having both fertile and sterile leaves, of which the latter are simply pinnate, occurs in the Continental Eocene and Miocene. Curiously enough, the South American genus *Hewardia* is found in the Upper Eocene of Bournmouth. *Woodwardia*, now represented by eight species from the warmer regions of the world, occurs in the Pliocene and Miocene of Europe, the species from the former, and perhaps also that from the latter, horizon being identical with an existing type; this genus also occurs in the Miocene of the United States. *Asplenium*, which at the present day numbers some 300 species, occurs commonly throughout the European Tertiaries, and is also found in the Cretaceous; some of the species being allied to existing European forms, while others are more nearly related to those of the tropics. It appears, moreover, that Ferns from the Jurassic of Siberia and the Jurassic and Rhætic of Europe, described under the name of *Cladophlebis* and *Alethopteris*, are referable to this genus. Ferns of this genus also occur in the English Wealden; in both the Lower (Damuda) and Upper (Raj-

Fig. 1368.—Lateral branches of the leaves of *Thrysopteris Murrayana*; from the Inferior Oolite of Yorkshire. Enlarged leaflets, with sori, are shown in the lower figure.

mahal) Gondwanas of India; and in certain New Zealand beds, correlated by Baron von Ettingshausen with the Trias. In the last subfamily, or the *Aspidieæ*, the cosmopolitan *Aspidium* and the allied *Lastræa* occur commonly from the Middle Tertiaries upwards.

FOSSIL FAMILIES.—An enormous number of Palæozoic and Mesozoic Ferns belong to this series, but only a few of the more important types can be even mentioned. The *Sphenopterideæ* comprise a number of Ferns, mostly of very delicate structure, and extremely difficult to classify. They are usually multipinnate, with the pinnæ in some cases dichotomous; at least the terminal leaflets are narrowed at the base; while all are often lobate, and with the veins dividing in a pinnate or forkèd manner from the base. The fructification of some forms has been described by Mr Kidston, and it is suggested that one or more of the genera may be allied to the existing *Hymenophyllaceæ*. Many of the species have exceedingly delicate fronds. Among the Carboniferous genera may be mentioned *Sphenopteris* (fig. 1369), *Calymmatotheca*, *Zeilleria*, *Urnatopteris*, in which there are fertile and sterile leaves, *Oligocarpia*, *Renaultia*, *Rhachopteris*, *Sphenopteridium*, and *Eremopteris* (fig. 1370). Of these, the first ranges from the Devonian to the Lower Jurassic of Europe, and is also found throughout a large part of the Indian Gondwanas, in the African Karoo system, in the Australian Hawkesbury beds, in New Zealand, and the Palæozoic of the United States.[1] *Eremopteris* also occurs in the Indian Gondwanas, and ranges in Europe to the Permian; and a Fern from the Kimeridgian of France has been named *Stenopteris*.

Fig. 1369.—Part of a leaf of *Sphenopteris trifoliata*; from the European Carboniferous. (After Schimper.)

The family *Archæopterideæ* (*Palæopterideæ*) was placed by Schimper in the present serial position; but the recent observations of Mr Kidston upon the type genus appear to indicate that it should be transferred to the Stipulatæ—although, until the necessity for such transference be absolutely proved, it appears preferable to leave the family in its old position. The leaves are bipinnate, and both these and the leaflets are usually stalked; the leaflets being broad and often lobate. The type genus *Archæopteris*, which has

[1] Ferns from the Laramie beds and American Tertiaries have been referred to this genus.

also been generally known by the preoccupied name of *Palæopteris*, occurs in the Devonian and Carboniferous of both Europe and the United States. According to Mr Kidston, it has stipules on the leaves, and its fructification appears to consist of sporangia devoid of annuli, and closely resembling those of the *Marattiaceæ*. The genus *Aneimeites*, from the Devonian of Canada, has been placed by Sir J. W. Dawson and Mr Kidston in the same family; which is

Fig. 1370.—*Eremopteris artemisiæfolia*; from the Carboniferous.

also taken to include *Triphyllopteris*, from the European Carboniferous. The latter genus has both fertile and sterile leaves.

With the important family of the *Neuropteridеæ* we return to the consideration of true Filices. In this group the leaves vary from a simple to a tripinnate type; the leaflets being either long or ovoid, and often narrowed at the base, with the midrib disappearing towards the extremity, and the veins equal, and in typical forms rising at an acute angle. The genus *Neuropteris* (fig. 1371) is a bipinnate type very common in the Carboniferous, but also extending into the Permian of Europe. The allied *Cyclopteris* (which is not admitted by Mr Kidston as a distinct genus) extends in Europe from the

Carboniferous to the Rhætic, and is also found in the upper part of the Lower Gondwanas of India (fig. 1372). The leaf has sub-

Fig. 1371.—*Neuropteris heterophylla*; from the Coal-measures of Europe. The lower figure shows a single leaflet enlarged.

orbicular leaflets resembling those of the existing Maiden-hair fern, with no midrib, and the veins numerous and dichotomising as they radiate to the margin. The typical Carboniferous forms, according to Mr Seward, have pinnate leaves, but in the figured Rhætic form referred by Dr Feistmantel to this genus they are bipinnate. *Neuropteridium* (fig. 1373) is a simply pinnate form occurring in the Lower Trias of Europe, and in the base of the Lower Gondwanas. *Dictyopteris* includes

Fig. 1372.—Part of leaf of *Cyclopteris pachyrhachis*; from the Panchet stage of the Lower Gondwanas of India. (After Feistmantel.)

Carboniferous ferns with a net-like venation as in *Glossopteris* (fig. 1376). Finally, Mr Kidston includes in this family the simply pinnate *Cardiopteris*, of the Lower Carboniferous, in which the somewhat heart-shaped leaves are devoid of a midrib. The *Odontopterideæ* form a well-defined family with bi- or tripinnate leaves, in which the leaflets are attached by the whole width of their base; the leaflets are non-lobate, with their veins proceeding wholly from the base, or in part from an indistinct midrib. The type genus

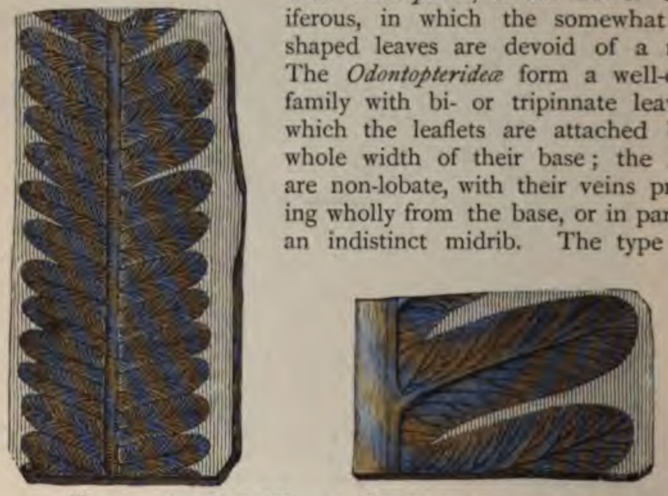

Fig. 1373.—Part of leaf of *Neuropteridium elegans*, and two leaflets enlarged; from the European Trias.

Odontopteris (fig. 1374) occurs in the Carboniferous and Permian, the figured species being common to Europe and North America.

Fig. 1374.—Part of leaf of *Odontopteris osmundæformis*; from the Carboniferous of Europe.

The bipinnate *Ctenopteris* (fig. 1375), from the Rhætic and Lower Lias, has leaves curiously resembling those of the Cycadaceous

Bowenia. The *Alethopterideæ* are multi-pinnate ferns with a strong general resemblance to the existing *Pteris*, and at least some of which have a similar marginal fructification. The leaflets are attached by their whole base, the bases of adjacent leaflets being united; and the midrib is complete. *Alethopteris*, of the Carboniferous and Permian, is common to Europe and the United States; the Mesozoic forms described under this name having been noticed under the head of *Asplenium*. *Lonchopteris*, of the Carboniferous, is distinguished by its net venation; while we have another type in the Permian *Callipteris*. Another multi-pinnate type is constituted by the *Pecopterideæ*, which agree with the last family in the attachment of the leaflets, with the exception that the adjacent bases are usually distinct; the midrib, although slender, continues to the extremity; and the veins arise less obliquely than in the *Neuropterideæ*. The typical *Pecopteris*

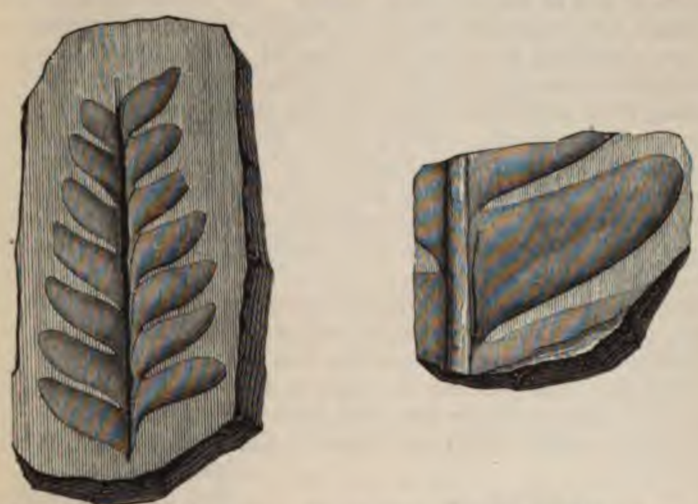

Fig 1375.—A pinna of *Ctenopteris cycadea*; from the Lower Lias. The right-hand figure shows an enlarged pinnule or leaflet.

contains a very large number of species, some of which are tree-like, from the Devonian and Carboniferous of both Europe and North America; and many of which have been referred to the *Marattiaceæ* under the names of *Asterotheca*, *Stichopteris*, &c., but which Mr Kidston considers to be generically inseparable. It also occurs in the Trias of Europe, and in Lower Mesozoic beds in New Zealand. Other Carboniferous genera are *Mariopteris*, *Callipteridium*, and *Dactylotheca*. In the Mesozoic we have also a large number of forms which may be provisionally placed here, although it is probable that at least a moiety belong to existing families. One series has been named on the evidence of sterile, and the other on that of fertile leaves, and there is accordingly a considerable probability that different genera have been named from a single species. Of the former series a fern from the Keuper and the Panchet series of the Indian Gondwanas has been described as *Pecopteris concinna;* and we also have *Lepidopteris* from the Rhætic, *Merianopteris* from the Keuper and the Damuda series of the Gondwanas, *Anomopteris* of the Keuper, and *Crematopteris* of the Bunter. In the second series, where the leaves consists of palmate branches on a long stalk, we have *Lacopteris*, *Matonidium*, *Marzaria*, *Andriana*, &c. The *Pachypteridea* are Mesozoic ferns, with small leaves, and include the Liassic *Dichopteris*, and the Oolitic *Scleropteris* and *Stachypteris; Pachypteris* itself being a doubtful form probably based upon remains of two of the preceding genera. The fructification of some of these Ferns resembles that of the existing tropical Polypodiaceous genus *Onychium*, to which they may be allied. In the present family Dr Feistmantel would include *Thinnfeldia*, a peculiar genus having thick leaves, which may be only simply pinnate, with lobate pinnæ; and occurring typically in the Rhætic and Lower Lias, but also found in the Indian Panchets, in the reputed Trias of New Zealand, in the Hawkesbury and overlying beds of Australia, and also in Argentina. The *Lomatopteridea* include a few Mesozoic ferns of allied types, having thick fleshy leaves, which are usually simply pinnate, with lobation of the pinnæ. Exclusive of the last-named genus this family contains *Lomatopteris*, extending from the Bath Oolite to the Kimeridgian and probably the Wealden; and *Cycadopteris*, which ranges from the Lias to the Upper Jurassic.

With the *Tæniopteridea* we come to a family easily recognisable by their usually simple strap-like leaves (fig. 1376), with a well-developed midrib, which are curiously like those of the Plaintain (*Musa*). It may be divided into two subfamilies, according to the venation. In the first subfamily, with a normal venation, *Tæniopteris* is represented by a few European and North American Carboniferous species, and also occurs in the Trias of Europe and New Zealand. The allied *Macrotæniopteris* comprises some very large ferns, ranging in Europe from the Keuper to the Lower Lias, and doubtfully to the Inferior Oolite, while it occurs in India in both the Upper

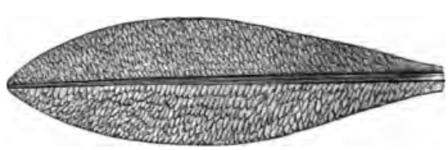

Fig. 1376.—Leaf of *Glossopteris retifera;* from the Lower Gondwanas of India. Reduced. (After Feistmantel.)

and Lower Gondwanas, and is also found in New Zealand and Australia. *Palæovittaria* seems peculiar to the Damuda series of the Lower Gondwanas. *Oleandridium* has stalked leaves differing somewhat in their venation from the preceding, and is considered to be allied to the existing *Oleandra* among the *Aspidieæ;* it occurs in the European Mesozoic and the Panchets. *Angiopteridium* and *Marattiopsis* are distinguished by a simple pinnation of the leaves; the former occurring in the Damuda series of the Gondwanas, and the latter in the European Carboniferous. The genus *Glossopteris* (fig. 1376) is the only representative of the second subfamily, and is distinguished by its net-like venation, retaining, however, the well-marked midrib characteristic of the family. It is extremely abundant in the Indian Gondwanas, ranging from the Talchir to the Upper Jurassic Jabalpur stage, and is also met with in the Hawkesbury beds of Australia, in the upper part of the African Karoo system, in the Cretaceous of Russia, and in beds of unknown age in Italy. Finally, the *Gangamopterideæ*[1] include Ferns with a net venation, in which the leaves are subject to great variation in shape, but may be digitate or fan-like, and devoid of midrib. There is one division with simple, and another with compound venation. In the former we have *Gangamopteris*, ranging throughout the Lower Gondwanas and also found in the Bacchus-Marsh beds of Victoria; and *Belemnopteris* of the *Damudas;* both being probably allied to the *Polypodiaceæ*. In the second group *Camptopteris* occurs in the Keuper; *Dictyophyllum* ranges from the Rhætic of Germany to the Cretaceous of Greenland; while *Clathropteris* is confined to the Rhætic, and *Protorhipis* to the Lias.

FERN-STEMS.—Omitting a few fossil Ferns of uncertain affinities, brief reference must be made to a few types of large size described upon the evidence of portions of the stem, but which cannot at present be definitely classed. Of these *Megaphyton*, from the Carboniferous of Europe and the United States, is founded on trunks of Tree-ferns, which bore their large leaves in a row on either side of the stem, and which Sir J. W. Dawson considers very unlike any existing type. *Psaronius*—a type common to the Old and New Worlds, and mainly of Devonian age—is founded on trunks of Tree-ferns marked by alternate leaf-scars, which are usually surrounded by aerial roots like those of many existing forms. *Caulopteris*, which is likewise found in both Europe and North America, is characterised by its vertically elongated leaf-scars. It ranges from the Carboniferous to the Permian; but at least some of the forms described under the name of *Ptychopteris*, which extends upwards to the Trias, are not generically separable. *Protopteris*, of the Cretaceous of Europe and Greenland, is another large form,

[1] Usually termed *Dictyopteridæ*, but not including *Dictyopteris* (p. 1507).

characterised by the bases of the leaf-stalks remaining attached to the scars, as in many recent Tree-ferns. Other forms are *Cyatheopteris* of the Bunter, and *Thamnopteris* ranging from the Permian to the Keuper; the latter having persistent leaf-stalks. Finally, *Rhizomopteris* of the Carboniferous, and *Sphallopteris* of the Bunter, are based on specimens generally regarded as rhizomes of large creeping ferns. The genus *Palæopteris*, from the Carboniferous, which was long considered to be a fern, is named from a specimen which appears to be the stem of one of the *Cordaiteæ*.

ORDER 3. RHIZOCARPEÆ.—The Rhizocarps are distinguished from the Ferns by the development of two kinds of spores termed *macrospores* and *microspores*. Their young shoots may be either straight, or circinate as in Ferns and *Psilophyton* (fig. 1378).

Although the macrospores and microspores are true spores, as developing plants without fertilisation, yet they may be regarded as incipient sexual elements, and thus throwing back the sexual differentiation to an early stage. Thus the microspores, or male elements, develop only male prothallia, which produce antheridea; while the macrospores, or female elements, develop female prothallia, which produce only archegonia.

The four existing genera of this order are aquatic plants, which may be simply floating, or may have a creeping rhizome. Of the *Salviniaceæ* the rootless genus *Salvinia* is represented in the Upper and Lower Miocene of the Continent, and also in the Laramie and higher beds of America. Of the two existing genera *Pilularia* (Pillworts) and *Marsilia*, constituting the family *Marsiliaceæ*, it is probable that a species of the former occurs in the Upper Miocene of Œningen, while *Marsilia* is recorded from the Miocene of Oregon in the United States, and also from the Lower Miocene of Ronzon near Puy-en-Velay. It has been suggested that *Sagenopteris*, ranging in Europe from the Rhætic to the Lower Jurassic, and also occurring, together with the allied *Dactylopteris*, in the Damudas of India, may be more or less closely allied to the *Marsiliaceæ*. They are plants of considerable size, with long-stalked leaves terminating in a palmate expansion of four or more members. *Marsilidium*, of the Wealden, has also been referred to the same family.

Sir J. W. Dawson considers that in the early Palæozoic the characters afterwards separated in the Club-mosses, Horse-tails, and Ferns were united in the Rhizocarps, and it will accordingly be convenient in this place to notice certain Palæozoic plants apparently more or less closely allied to the Rhizocarps, some of which should probably be included in the same order, while others may be intermediate types connecting that order with the Equisetaceæ and Lycopodiaceæ. In the first place, as previously noted (p. 1484), certain spherical bodies known as *Sporangites* occurring the Devonian and Carboniferous of North America and Europe, : regarded by Sir J. W. Dawson as macrospores or sporocarps of iizocarps, under the name of *Protosalvinia*. Better known is the nus *Sphenophyllum* (fig. 1377), likewise curring on both sides of the Atlantic, d ranging from the Ordovician to the Carniferous, which many authorities now agree provisionally placing in this order, although iers would refer it to the Equisetaceæ. iey were small plants with wedge-shaped ives arranged in regular whorls, after the inner of the existing *Marsilia*. Another be which is regarded by Dr Feistmantel as osely allied to the preceding is *Trizygia*, own by a single species from the Lower ondwanas of India. These plants (if com:te) are comparatively small, with a slender :m bearing incomplete whorls of wedgeaped leaves; each whorl occupying only three sides of the stem, d consisting of six leaves arranged in three dissimilar pairs. They re probably aquatic.

Fig. 1377.—Leaf of *Sphenophyllum antiquum*; from the Devonian of Canada. Enlarged and natural size. (After Dawson)

Here also, according to Sir J. W. Dawson, should be placed the nus *Ptilophyton* (fig. 1378), which appears to be most nearly

Fig. 1378.—*Ptilophyton plumosum*; from the Lower Carboniferous of Nova Scotia. The right-hand figure shows a portion magnified. (After Dawson.)

ied to the Rhizocarps. The genus ranges in North America from e Middle Devonian to the Lower Carboniferous, and is also found the Old Red Sandstone of Scotland. These organisms, which ve been referred to the Algæ and Lycopodiaceæ, are composed feather-like leaves, apparently bearing macrospores on parts of e stem or petioles. They are considered to have been of aquatic habits, the linear pinnæ of the leaves acting as floats. Finally, there remains for consideration the imperfectly-known plants from the Ordovician (Arenig beds) of England to which the hybrid name *Protannularia* has been given; and which were originally referred to the Thallophytous genus *Buthotrephis*. They consist of slender branching stems bearing at intervals whorls of linear leaves (fig. 1379), somewhat resembling those of the Equisetaceæ, to which class they may be more or less closely allied.

Fig. 1379.—A leaf-whorl of *Protannularia Harknessi*; from the Ordovician of the North of England.

Class II. Equisetaceæ.—With this group we come to a small class now represented by only a single genus with species of comparatively small size, but which in the Palæozoic contained numerous forms of large dimensions, and occupying an important position in the contemporary vegetation. The class may be briefly characterised by the rudimentary condition of the leaves, which are reduced to small sheathing whorls, borne either on the stem or on branchlets also arising in whorls from the joints of the barren stem. The sporangia, which produce only one kind of spores, are borne upon specially modified leaves forming a terminal spike to the main stem (fig. 1381, A), there being distinct fertile and barren stems.

Fig. 1380.—*Schizoneura gondwanensis*; from the Damuda series of India. Much reduced. (After Feistmantel.)

The existing family *Equiseteæ* comprises small forms, characterised by their perennial rhizome, from which the annual stems arise. The single existing genus *Equisetum* (Horsetails) occurs in most parts of the world, with the exception of Australasia; and seems to have commenced in the Lower Keuper, where species of much larger size than their existing analogues are met with; and from this period representatives occur throughout most of the European Mesozoic and Tertiary strata and also in some of those of North America, and in the Lower Mesozoic of New Zealand. The Carboniferous *Equisetites* seems to have been an allied genus.

The extinct family *Schizoneureæ* is typically represented by the genus *Schizoneura* (fig. 1380), which occurs throughout the European Trias, and perhaps also in the Jurassic, and in the Lower Gondwanas of India. According to Dr Feistmantel, these plants are characterised by the sheaths found at the joints of the stalks, which in an early stage of development consist of a number of leaflets, with median veins, and attached by their margins. In the course of development these sheaths split either into thin component leaflets, or more frequently into two equal and opposite portions (as in the figure), which thus simulate paired leaves. The stems and stalks are longitudinally ribbed. *Phyllotheca*, which occurs in Europe from the Lias to the Lower Jurassic, in the Lower Gondwanas of India, and the Newcastle beds of Australia, seems to be more nearly allied to *Equisetum*, but is placed by Schimper in this family. The joints of the stem are of moderate length, and the outer surface is fluted; while the leaves are linear, and free at their extremities, but at the base are united in a sheathing whorl, which may be longer than the joints of the stem. Each leaf has a midrib.

With the *Calamiteæ* we come to another extinct family, which is confined to the Palæozoic, and contains the largest representatives

Fig. 1381.—Restoration of *Calamites*, greatly reduced. A, *C. Suckowii*; B, *C. Cistii*. (After Dawson.)

Fig. 1382.—Leaves and branchlets of *Calamites ramosus* (*Asterophyllites foliosa*); from the Carboniferous of England. Reduced. (After Lindley and Hutton.)

of the class, some of the species probably attaining a height of about 30 feet. Their stems are tall and cylindrical, with a hollow pith-cavity divided into sections by diaphragms, and bearing at the joints either whorls of needle-like leaves (fig. 1381, B), or branchlets carrying secondary whorls of leaves (fig. 1381, A). In transverse section these stems show radiating bundles of fibres, resembling those of Conifers, and showing great variation of structure in the different forms. The base of the stem generally terminates in a blunt point (fig. 1384), and it may be attached to the rhizome, or several stems may spring from a common stock, as in the restoration figured. The roots are cylindrical, and may be branching. There has been great confusion in regard to the determination of Calamites owing to the difficulty of referring fruits, leaves, and roots to their respective stems; and also owing to the fact that while in some cases the entire stem is preserved, in others only a cast of the pith-cavity remains. According to Mr Kidston the well-defined genera based on stems are *Calamites*, ranging from the Carboniferous to the Permian; *Calamocladus* and *Asterocalamites*, of the Devonian and Carboniferous; and *Arthropitys*, of the Permian. At least some of the specimens to which the names *Annularia* and *Asterophyllites* (fig. 1382) have been applied are branchlets of *Calamites*. Fruits of *Asterocalamites* have been described as *Pothocites*; while others known as *Stachannularia* have been found attached to the branchlets of *Annularia*. Other fruits described as *Volkmannia*, *Calamostachys*, and *Macrostachya* are probably likewise referable in many instances to *Calamiteæ*, although it has been suggested that some may belong to *Sphenophyllum*. Roots known as *Pinnularia* have been found attached to *Calamites*, but some of the specimens to which this name has been applied may belong to other plants. There has been considerable discussion as to the nature of the outer surface of the bark of *Calamites*, but it appears from the most recent observations that in species with thin bark this surface was fluted, while in those with thick bark it was smooth.

Fig. 1383.—Part of stem of *Calamites cannæformis*; from the Carboniferous of Europe. Reduced.

A large number of synonyms in addition to those already mentioned have been made; among which it may be observed that Mr Kidston includes *Asterophyllum*, or *Asterophyllites*, and *Archæocalamites* in *Asterocalamites;* while *Calamodendron* is regarded as inseparable from the type genus. *Calamiteæ* occur both in Europe and North America, but are unknown in India and Australia.

According to Sir J. W. Dawson, "it would seem, from the manner in which dense brakes of these Calamites have been preserved in the coal-formation of Nova Scotia, that they spread over low swampy flats, and formed fringes on the seaward side of the great Sigillaria forest. In this way they no doubt contributed to prevent the invasion of the areas of coal accumulation by the muddy waters of inundations, and thus, though they may not have furnished much of the material of coal, they no doubt contributed to its purity."

Fig. 1384.—Lower extremity of stem of *Calamites cannæformis;* from the European Carboniferous. Reduced.

Here may be noticed the remarkable jointed stem-like bodies known as *Vertebraria*, which are generally regarded as Equisetaceous, and occur throughout the Lower Gondwanas of India, and are also found in the Newcastle beds of Australia. These peculiar bodies, which are often branched, and may be of considerable size, are regarded as the rhizomes of an Equisetaceous plant of which the foliage is unknown. Their association in India with *Schizoneura* is noteworthy.

Class III. Lycopodiaceæ.—The third and last class of the Pteridophytes, known as Lycopodiaceæ or Dichotomeæ, is now represented by the Club-mosses and Selaginellas, and also includes a number of allied extinct types of much larger dimensions. These plants are characterised by a simple or branched stem, without joints, usually having roots, and bearing numerous small and simple leaves; while the branches of the stem and frequently of the roots divide dichotomously (fig. 1387). The sporangia are solitary, and borne either upon the upper surface of the base of the leaves, or in the axils of the latter, or simply upon the stem. The class may be divided into two orders.

Order 1. Isosporeæ.—The Club-mosses, which are the existing representatives of this order, are characterised by producing only one kind of spores, and by the absence of *ligulæ*, or membranes at the base of the leaves, as well as by certain other points which need no mention here.

The earliest plant referred to this order is *Psilophyton*, which is regarded by Sir J. W. Dawson as forming a connecting link between the Rhizocarps and the Lycopods, and probably forms the type of a distinct family, the *Psilophyteæ*. This genus, with which *Haliserites* is identical, occurs in the Lower Devonian of both Europe and the United States, and is a plant of more than average interest. It attains considerable dimensions, and has minute or rudimental leaves, which are numerous and spirally arranged on the barren stems, but are sparse or absent on the fertile ones. On decorticated stems their point of attachment is represented by minute scars. The young branches have circinate terminations (fig. 1385), like the "crosiers" of Ferns; while the rhizomes are circular, and show irregularly placed areolæ, to which the roots were attached. The inner structure of the stem consists of an axis of scalariform tissue, surrounded by cells. Finally, the fructification (fig. 1386) consists of naked oval sporangia, generally borne in pairs on lateral or terminal pedicels, which are regarded by Sir J. W. Dawson as making the nearest approach to the sporocarps of the Rhizocarps. *Arthrostigma*, from the Devonian of Canada, is placed by the same authority in this family.

Fig. 1385.—Circinate terminations of young branches of *Psilophyton princeps*. (After Dawson.)

Fig. 1386.—Reduced restoration of *Psilophyton princeps*; from the Lower Devonian of Canada. (After Dawson.)

The three existing families of the order—viz., *Lycopodieæ*, *Psiloteæ*, and *Phylloglosseæ*—are of but little palæontological importance; the last two being unknown in a fossil condition. *Lycopodium* occurs in the Jurassic; while in the Permian, Carboniferous, and Upper Devonian there occur allied forms for which the name *Lycopodites* has been proposed. The Devonian *L. Milleri* is, however, a *Psilophyton*. *Lycopodites* also occurs in Lower Mesozoic beds in New Zealand.

ORDER 2. HETEROSPOREÆ (LIGULATÆ).—This order, now represented by *Selaginella* and *Isoëtes*, is distinguished by developing two kinds of spores—viz., macrospores and microspores—and by the presence of ligulæ to the leaves. In both the prothallium is developed within the macrospore; thus almost suppressing the first or sexual generation. The family *Selaginelleæ* includes only the living genus *Selaginella*, which is mainly characteristic of the warmer regions, and especially of the southern hemisphere. The stem is flattened, with two

Fig. 1387.—*Lepidodendron Sternbergi*; from the Carboniferous. The left-hand figure shows a cone, and the right the extremity of a branch.

opposite rows of leaves, which are often of a glaucous hue, and the fruit is in the form of long spikes, arising from the axils of the leaves. It is considered probable that this genus is represented in the Coal-measures of the Continent by species which have been referred to *Lycopodites*, and it undoubtedly occurs in the Laramie series of North America.

With the *Lepidodendreæ* we come to the first of the two extinct families of the order, which contains gigantic forms characteristic of the Upper Devonian and Carboniferous. These were tree-like Lycopods with linear single-veined leaves, which leave rhomboidal scars, often very prominent, at their point of attachment to the dichotomously-branching stems. The fruit is in the form of scaly cones, bearing macrospores and microspores, which may be either terminal or lateral; and the young branches have a pith-cavity, surrounded by a layer of scalariform tissue, which sends out processes through the thick bark to the leaves. As is the case with so many Palæozoic types, the different portions of these trees have received distinct generic names. Thus the decorticated stems have been named *Knorria*, fruiting branches, *Halonia*, and cones (fig. 1388) *Lepidostrobus*, while at least some of the roots known as *Stigmaria* (fig. 1392) are referable to the present family. According to Sir J. W. Dawson, there is considerable difference in the mode of growth of the outer surface in different members of the family.

"Thus in some species the areoles, at first close together, become, in the process of the expansion of the stem, separated by intervening spaces of bark in a perfectly regular manner; so that in old stems, while widely separated, they still retain their arrangement, while in young stems they are quite close to one another. This is the case in *Lepidodendron corrugatum*. In other species the leaf-scars or bases increase in size in the old stems, still retaining their form and their continuity to one another, as in *L. undulatum*, and those forms which have large leaf-bases. In these species the continued vitality of the bark is shown by the occasional production of lateral strobiles [cones] on large branches, in the manner of the modern Red-pine of America. In other species the areoles neither increase in size nor become regularly separated by growth of the intervening bark; but in old stems the bark splits into deep furrows, between which may be seen portions still retaining the areoles in their original dimensions and arrangement."

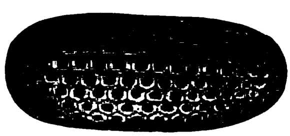

Fig. 1388.—Cone of a Lepidodendroid Tree (*Lepidostrobus Dabadianus*); from the Carboniferous. One-third natural size. (After Schimper.)

The majority of the genera are common to Europe and the United States, and some of them occur in other parts of the world, as in the Palæozoic of Australia, and the *infra*-Karoo series of South Africa. The type genus *Lepidodendron* contains a number of species with a most complex synonomy, and is characterised by its vertically elongated leaf-scars and slender branches. According to the views of Mr Kidston, the stems to which the name *Ulodendron* has been applied are mainly referable to *Lepidodendron*, although others may be Sigillarian; Sir W. Dawson has, however, identified *Ulodendron* with the next genus. *Lepidophlœus* (*Lomatophlœus*), which appears to be exclusively Carboniferous, has the leaf-scars transversely elongated, with three vascular points, and placed on distinct prominences; while the branches are thick, the leaves very long, and the cones always lateral. *Hallonia* is founded on fruiting branches of this genus; while fruits of one type of the so-called *Lepidostrobus* (fig. 1388) have been found attached to stems with the scars of *Lepidophlœus*. *Cyclostigma* and *Leptophlœum* are exclusively Devonian; the former being characterised by the circular or horse-shoe-like leaf-scars, and the latter by the flat and rhombic leaf-bases and obsolete scars. *Leptophlœum* occurs in the United States and Australia.

The existing genus *Isoëtes*, the sole representative of the *Isoëteæ*, is known in a fossil condition by two species from the Miocene of the Continent, and by a third from the Eocene of Colorado.

With regard to the serial position of the second great Palæozoic family of the *Sigillareæ*, there has been much discussion, but the general consensus of opinion seems now to be in favour of placing them in the present order; although it is quite probable that, as Sir J. W. Dawson suggests, at least some of them may be more or less closely allied to the primitive Gymnosperms. Their resemblance to the *Lepidodendreæ* is indicated by their strongly-marked external similarity; which is especially shown in the tall, slender, and dichotomously-branching stem (fig. 1389), the slender grass-like leaves, the leaf-scars arranged in whorls, and the Stigmarian roots. These trees, constituting the genus *Sigillaria*, are mainly of Carboniferous age, and are common to the Old and New Worlds; they attained very large dimensions, their stems being sometimes as much as five feet in diameter. Not unfrequently these stems are found in an erect position (fig. 1390), passing through several layers of rock; while in other cases they have been found attached to the Stigmarian roots which penetrate the clays underlying the seams of workable coal. The columnar

Fig. 1389.—A, Reduced restoration of *Sigillaria Browni*; B, Do. of *S. tessellata*; from the Carboniferous. (After Dawson.)

stems of the Sigillarians are marked by continuous longitudinal ribs, between which are the leaf-scars (fig. 1391), forming whorls round the stems. It will be seen from the figure that the arrangement of these scars is such that each one is placed in the interval between two scars of the horizontal rows immediately above and below; this arrangement, or *phyllotaxis*, obtaining in all plants with leaves forming whorls. The external coat of the stem is very hard, beneath which is an inner bark composed of cellular tissue traversed by rope-like fibres, while the woody central axis is small, and somewhat intermediate in structure between that of the Lepidodendroids and Gymnosperms. The roots (*Stigmaria*) usually start from the stem in four main branches, which divide dichotomously several times, and then continue in long extensions, which Sir J. W. Dawson considers are

Fig. 1390.—Stem of a semi-erect *Sigillaria* in a coal-seam; from Nova Scotia. (After Dawson.)

Fig. 1391.—Part of stem of *Sigillaria Utschneideri*; from the Carboniferous. The left-hand figure shows a small portion on a larger scale.

intended to afford a firm support in a soft marshy soil. The rootlets (fig. 1392) were arranged on the roots in whorls; and when they decayed they left scars on the bark (figs. 1392 and 1393) corresponding to the leaf-scars on the stems. The nature of the fruit is still unknown, but it is probable that it more or less closely resembled that of the Lepidodendroids. Sir J. W. Dawson has, however, suggested that some of the Sigillarians may have had

Fig. 1392.—Part of root of a Sigillarian or Lepidodendroid Tree (*Stigmaria ficoides*); from the Carboniferous. One-quarter natural size.

Fig. 1393.—Bark of a Sigillarian or Lepidodendroid root; from the Carboniferous. (After Dawson.)

fruit of the type of *Trigonocarpus* (fig. 1400), and that such forms consequently exhibit a connecting link between the Pteridophytes and the Gymnospermous Phanerogams.

The genus may be divided into several groups, which may eventually have to be raised to generic rank. The Clathrarian group (in which Mr Kidston includes some species of *Ulodendron*) has a thin bark, with the leaf-scars not in distinct rows, but having a spiral appearance; type, *S. discophora*, of Europe and the United States. In the Liodermarian group the ribs on the bark are obsolete, and the leaf-scars in distinct rows; type, *S. sydnensis*, of Australia. In the third, or Rhytidolepidian group, in which the Favularian group may be included, the ribs are narrow (fig. 1391) and often striate, and the leaf-scars large and hexagonal, or shield-shaped; type, *S. tessellata* (fig. 1389, B). Finally, the typical group is characterised by the broad ribs to the bark, of which the width usually exceeds that of the oval or elliptical leaf-scars; types, *S. reniformis* and *S. Browni* (fig. 1389, A).

CHAPTER LXVII.

SUB-KINGDOM CORMOPHYTA—continued.

SERIES PHANEROGAMÆ.—CLASS GYMNOSPERMÆ.

SERIES III. PHANEROGAMÆ.—The Phanerogams, which include the whole of the remaining groups of plants, are characterised by the production of a seed, and the consequent concealment or compression of the alternation of generations. It has already been mentioned that in several groups of Pteridophytes the tendency of the oöphore (prothallium) is to lose its independent existence, but in the present series this independence is totally suppressed. Thus the macrospore or female element, now termed the ***embryo-sac***, is never detached from the main plant, or sporophore, previous to fertilisation; while the oöphore, now known as the ***endosperm***, which may be rudimentary, is always enclosed in the macrospore (embryo-sac). The seed is developed from the *ovule* (of which the envelope is known as the *testa*), which produces the embryo-sac, and in this the endosperm and the *oösphere*. The latter is fertilised by the *pollen-tube* or outgrowth from the *pollen-grain*, which represents the microspore of the Pteridophytes.[1] The plant is always differentiated into stem, leaves, roots, and hairs; and its branching is normally monopodial, the main axis continuing to grow and producing its lateral shoots and roots beneath its apex. Phanerogams are further characterised by the metamorphosis and differentiation of homo-

[1] It is thus evident that the Phanerogam with its pollen-grains and embryo-sacs is equivalent to the sporophere of the Pteridophytes. The sexual differentiation, which in the most specialised members of the latter commences with the formation of macrospores and microspores, is, however, carried further back, being manifested not only in the formation of embryo-sac and pollen-grains, but also in the differences between ovule and pollen-sac, and between the modified leaves (*carpels* and *stamens*) bearing them, and, even earlier, in the distinction between male and female flowers, and finally in the development of separate male and female (*diœcious*) plants. At least for a time, the seed unites in itself the two generations—the prothallium (endosperm), and the embryo or young plant of the second generation. (Sachs.)

logous structures for the purpose of reproduction, as is shown in the flower, into the complex structure of which it will be unnecessary to enter here. The differentiation of the tissues is also more complex than in the Pteridophytes.

Phanerogams include the highest types of plant life, and it will be seen from the sequel how there has been a gradual advance in their degree of organisation as we ascend in the geological scale; the most specialised groups only making their appearance at a late epoch.

CLASS I. GYMNOSPERMÆ.—The first and most generalised class of Phanerogams is characterised by the ovules and seeds not being enclosed in the ovary, and by the early development of a distinct endosperm forming archegonia in which the oöspheres originate. The first leaves produced from the embryo are arranged in whorls of two or more; and the wood grows from the outside, forming annual rings of growth.

In many respects the existing Gymnosperms are intermediate between the Pteridophytes and the Phanerogams; and it is practically certain, as we have already hinted, that in past times there was a complete transition between the two series. The class includes the Cycads and Conifers and dates from the Devonian; but in the middle Mesozoic, which has hence been termed the "age of Gymnosperms," it attained its highest stage of development, and constituted the dominant type of the flora. The existing forms are usually arranged in three orders, while a fourth is frequently made for the reception of the extinct *Cordaites.*

ORDER I. CYCADACEÆ.—Existing Cycads (fig. 1394), which occur in the warmer regions of America and Asia, and also in South Africa

Fig. 1394.—A male Cycad (*Macrozamia spiralis*); from Australia. Greatly reduced.

and Australia, are low palm-like trees, with a short unbranched stem, occasionally divided into two, marked by leaf-scars. The leaves form a crown, and, except in one genus where they are bipinnate, are simply pinnate; their structure is very firm, and they usually develop in a circinate manner like ferns. The plants are male and female; the male fructification being borne in cones (fig. 1394), while in the female the ovules are usually situated on the margin of modified leaves or on the base of scales.

Existing Cycads are divided into the families *Cycadeæ*, *Encephalarteæ*, *Stangerieæ*, and *Zamieæ*. Of these the living South African genus *Encephalartos* occurs in the Miocene of Eubœa, and perhaps in the Rhætic of Honduras; while a leaf from the Miocene of Styria has been referred to the Mexican genus *Ceratozamia*, belonging to the *Zamieæ*.

The family position of extinct genera is for the most part uncertain, and it is accordingly unadvisable to make any attempt at such divisions. As is usually the case with fossil plants, genera have been founded upon different portions of the organism, so that in many cases we doubtless have the same type described under two or more names. In the Mesozoic, as Sir J. W. Dawson remarks, Cycads had a world-wide distribution, and many of the undermentioned European genera likewise occur in America. The species occurring in the Cretaceous of Greenland are, according to the same authority, of small size and low growth, so that they may have been protected from the winter snows. Some of the more southern forms attained, however, a considerable height, and must have resembled palms. The order is known from the Carboniferous upwards.

Genera founded on Leaves. — The genera based on the evidence of leaves will be taken first. Of these *Cycadites* has the leaflets attached by the whole width of their base to the stem, with a single vein, while the young leaves are circinate; in all of which respects it approximates to the existing *Cycas*. It occurs in Europe from the Carboniferous to the Upper Cretaceous; and in India it is characteristic of the Upper Gondwanas. *Podozamites* with small leaves, and the leaflets alternating and narrowed at the base, ranges in Europe from the Rhætic throughout the Jurassic and into the Lower Cretaceous; it is also found in the Dakota Cretaceous, in the Upper Gondwanas of India, and in the reputed Trias of New Zealand. Till something is known of its fructification the affinities of this genus cannot be determined. *Zamites*, again, is a very large genus with small or medium-sized leaves, in which the leaflets are attached by a calus to the upper surface of the stem, and are subject to a considerable variation of form. In Europe this genus is well represented from the Middle Trias to the Upper Cretaceous (Greenland), an isolated species being found in the Miocene. It is also recorded from the reputed Trias of New Zealand, and the Upper Gondwanas of India. *Glossozamites* includes large-leaved Cycads with subsymmetrical leaflets, occurring typically in the European

Wealden, but according to Dr Feistmantel also represented in the Lias and the Lower Gondwanas of India. *Ptilophyllum* (fig. 1395) is a genus characteristic of the Upper Gondwanas, having long narrow leaves, with alternating leaflets which are likewise long and narrow, and are attached to the front of the stem, with upwardly-directed terminal points, and a simple venation. *Otozamites* (fig. 1396),

Fig. 1395.—Part of leaf of *Ptilophyllum cuchense*; from the Upper Gondwanas of India. (After Feistmantel.)

Fig. 1396.—Part of leaf of *Otozamites bengalensis*; from the Lower Gondwanas of India. (After Feistmantel.)

according to the last-named writer, is allied to *Ptilophyllum*, but distinguished by the lower basal angle of the leaflets, which in the latter is affixed and decurrent on the stem, becoming free and rounded like the upper one; the disposition of the veins being very similar in both genera. In Europe this genus occurs very abundantly from the Rhætic to the Upper Jurassic, is well represented in the Cach stage of the Upper Gondwanas of India, and also occurs in the Rhætic of Honduras. *Ctenophyllum* is an allied genus typically from the Upper Lias and Lower Jurassic of Europe. An important genus is *Pterophyllum*, in which Dr Feistmantel includes *Anomozamites* of Schimper, occurring in Europe from the Carboniferous to the Upper Jurassic and Wealden, in India from the higher stage of the Lower Gondwanas to the two lower divisions of the Upper Gondwanas, and also recorded from the reputed Trias of New Zealand. The leaves are stalked, of moderate size, and considerable width; while the leaflets are generally opposite, articulating at right angles with the sides of the stem, and having numerous veins. *Ptilozamites* is an allied type from the Rhætic of the Continent. *Nilssonia*, of the Rhætic and Lower Jurassic of Europe, is readily distinguished by its leaves being either strap-like and undivided, or with slight segmentation. *Sphenozamites* from the French Jurassic and the Rhætic of Honduras, and *Macropterygium* from the Keuper of Carinthia, are imperfectly known forms which may be allied to *Nœggerathia* noticed below. *Dictyozamites* is a peculiar form from the Upper Gondwanas characterised by the leaves having a net-like venation, as in the genus *Glossopteris* (fig. 1376) among the Ferns, and is regarded by Dr Feistmantel as the type of a distinct family. Another type is presented by the genus

Rhiptozamites from the Jurassic of Siberia, to which *Næggerathiopsis* of the Lower Gondwanas of India, the Hawkesbury beds of Australia, and the Rhætic of Honduras, is closely allied, if indeed it be generically separable. It is known by specimens which appear to be leaflets of a pinnate leaf, and are of an elongate form with forked radiating veins which do not converge towards the summit.

GENERA FOUNDED ON THE FRUCTIFICATION.—The name *Cycadospadix* has been applied to the female fructification of Cycads from the Lower Lias and Corallian closely resembling that of *Cycas*. Cones from the Lias to the Wealden have been described as *Zamiostrobus* and *Beania;* while seeds, ranging from the Keuper to the Wealden, are known as *Cycadeospermum*.

GENERA FOUNDED ON STEMS.—Stems of Cycads are of not uncommon occurrence, especially in fresh-water deposits, and are locally known to the quarrymen of the south of England as "fossil birds'-nests." According to the arrangement of Count Saporta they may be classified as follows: *Bolbodium*, from the Lias and Corallian; *Cylindropodium*, from the Lower Lias and Upper Jurassic; and *Mantellia* (fig. 1397), also known as *Cycadoidea* or *Clathropodium*, from the Upper Jurassic and Wealden, which is especially common in the "dirt-bed" of the Isle of Portland. Other stems, ranging from the Jurassic to the Lower Greensand, have been described by Mr Carruthers under the name of *Bennettites;* the associated fructification differing in several respects from that of existing types. The preceding forms have comparatively short stems, but in *Platylepis*, of the Lias, and *Fittonia* and *Bucklandia*, of the Upper Jurassic and Wealden, the stems may attain a height of several feet.

Fig. 1397.—Stem of *Mantellia megalophylla;* from the Purbeck of the Isle of Portland. Reduced.

Here we may notice the remarkable genus *Williamsonia*, ranging from the Rhætic to the Jurassics of Europe, in regard to the serial position of which there has been much discussion. It is based on the fructification, which in some cases is found attached to stems with spirally arranged leaves. It has been suggested that this plant may belong to the Dicotyledons, while Mr J. S. Gardner considers that its affinities are with the monocotyledonous *Pandanaceæ;* but it appears quite possible that it may really prove to be an extremely aberrant Cycad. This genus is also found at the base of the Upper Gondwanas of India.

Transitional Types.—The families *Nœggerathieæ* and *Cordaiteæ*, of the Palæozoic, appear to include types which are in many respects transitional between the existing Cycads and Conifers, and may therefore provisionally occupy an intermediate position. Both families are, indeed, referred by Mr Kidston to the Cycads, but other writers would place some or all of these forms with the Conifers. In the first family the type genus *Nœggerathia*, which occurs in the European and North American Carboniferous, has the leaves arranged in two opposite rows (distichous), these

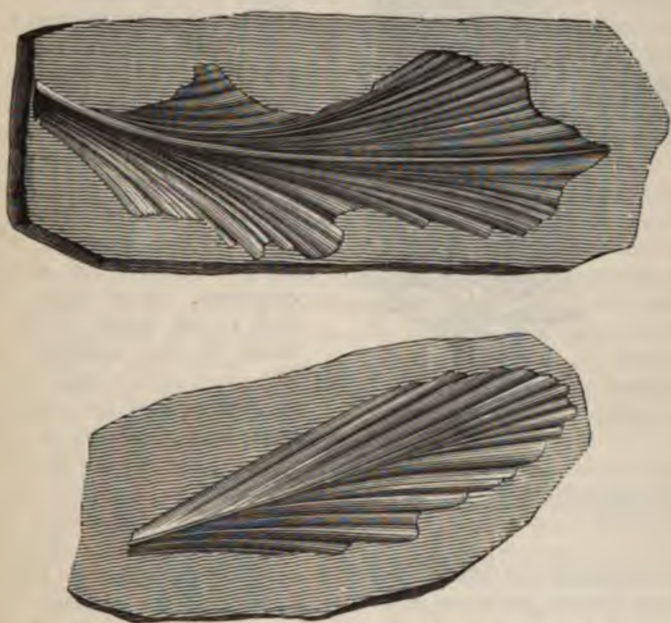

Fig. 1398.—Leaves of *Psygmophyllum expansum*; from the Permian of Russia.

leaves having a cuneiform base, with radiating veins which do not form forks. *Psygmophyllum* (fig. 1398), or *Gingkophyllum*, is an apparently allied type from the European Carboniferous and Permian, which is placed by Dr Schenk with the Taxoid Conifers. A branch from the upper Devonian of Wyoming, described by Sir J. W. Dawson as *Dictyocordaites* is stated to connect *Nœggerathia* with the under-mentioned genus *Cordaites*; since, in place of the parallel venation of the latter, the veins fork at an acute angle, and are slightly netted by the spreading branches of one vein uniting with those of an adjacent one. The second family is represented by the genus *Cordaites* (fig. 1399), ranging from the Devonian to the Permian, and occurring in both the Old and New Worlds. These plants formed trees reaching to a height of 20 or 30 feet, with the stems marked by transverse leaf-scars, and the leaves arranged in whorls; the leaves themselves (fig. 1399) being comparatively broad, with parallel longitudinal veins, and attached by a somewhat wide base. Their fructification consisted of male and female catkins, forming long racemes (fig. 1399), and known as *Antholithus;* which subsequently produced berries known as *Cardiocarpus*, some of which appear to have had wing-like envelopes, while other types had a soft pulpy cover like those of the existing Yews. The stem had a large central pith surrounded by scalariform tissue with a cylinder of woody wedges; the casts of these pith-cavities are included among the so-called *Sternbergia*, to be shortly mentioned. According to Dr Schenk the female fructification of *Cordaites* is most like that of the Cycads, while the male fructification and the structure of the stem comes nearest to the Conifers.

Fig. 1399.—A branch of *Cordaites;* from the Carboniferous. Reduced. (After Grand' Eury.)

In this place certain Carboniferous fruits which have not at present been referred to their respective plants may be conveniently noticed. These have been named *Rhabdocarpus*, *Carpolithus*, *Trigonocarpus* (fig. 1400), and *Palæoxyris*. They are large and angulated nut-like fruits, resembling those of the Yews. Specimens of *Trigonocarpus* are extremely numerous in some of the coal-measures; a slab of sandstone in the British Museum measuring 21 × 15 inches containing more than 400 of these nuts. The sug-

Fig. 1400.—*Trigonocarpus Parkinsonsi;* from the Carboniferous of England. (After Lindley and Hutton.)

gestion of Sir J. W. Dawson that some of these fruits may belong to Sigillarians has been already mentioned, but most recent authorities agree in regarding them as belonging to *Cordaiteæ* or Conifers.

ORDER 2. CONIFERÆ.—This order includes the existing Yews, Pines, and allied forms, and is of considerable palæontological importance, although the different groups can be but very briefly mentioned in this work. Conifers are characterised by the strong and continuous growth of the main axis, which forms a slender conical stem sometimes exceeding 200 feet in height; on this main stem the lateral axes, or primary branches, arise either in rosettes at intervals, or irregularly, and again subdivide in the same manner; the whole contour of the tree thus forming a more or less regular cone. The leaves may be either all foliage leaves containing chlorophyll; or all colourless or brownish scales; or a mixture of foliage leaves and scales. The foliage leaves are mostly small and simple, and very rarely compound; and thus form a striking contrast to the Cycads, where the leaves constitute the greater part of the plant. The flowers are always of separate sexes; but the trees themselves may either bear one or both kinds of flowers. These flowers are never terminal on the main axis, and are subject to great variation of structure in the different families. The male flowers are not of much importance to the palæontologist, who has more often to deal with those of the female. The best known examples of the latter are the cones of the *Abietineæ*, which are modified shoots bearing a number of closely packed woody scales, on which the ovules are usually placed in pairs.

The earliest fossils referred to the Coniferæ are trunks of large trees occurring in Europe and North America, from the Carboniferous to the Permian, and described under the names of *Dadoxylon*, *Araucarioxylon*, or *Pinites*. These stems exhibit the woody structure characteristic of existing Conifers, and Sir J. W. Dawson states that they are found in association with leaves of Permian genera of *Walchieæ* noticed below, and consequently places them in that family. It has, however, been suggested that at least some of these stems belong to the *Cordaiteæ*, although strong reasons have been propounded against the acceptance of this view. Some of the curious ringed cylinders described under the name of *Sternbergia* or *Artisia* are casts of the pith-cavity of *Dadoxylon*. Stems from the coal-measures have been found with a length exceeding 70 feet.

Leaving these doubtful forms we may proceed to the consideration of the five existing families into which the order may be divided. The *Taxineæ*, or Yews and their allies, have their leaves, which are often of considerable width, arranged spirally; the flowers typically diœcious; and with the ripe seed enclosed in a fleshy envelope. We have already mentioned that *Psygmophyllum* (*Gingkophyllum*) is placed in this family by Dr Schenk; but exclusive of this form we have several genera allied to the existing *Salisburia* or Gingko-tree of Japan and China, characterised by its fan-like leaves (fig. 1401).

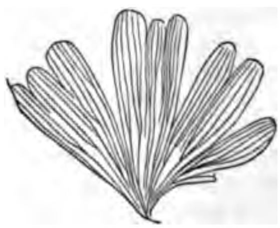

Fig. 1401.—Leaf of Gingko-tree (*Salisburia siberica*): from the Lower Cretaceous of Siberia. (After Dawson.)

This genus had an almost world-wide distribution in past times, being abundantly represented from the Permian, and if *Saportea*, from the Carboniferous of Pennsylvania, be rightly included, extending as low as the preceding period. It is very curious, as Sir J. W. Dawson remarks, that this genus should now be restricted to a single Asiatic species, although it will grow in temperate Europe and America, without, however, usually producing fruit. In India it occurs in the Upper Gondwanas. *Rhipidopsis*, from the Lower Jurassic of the Atlas and the Lower Gondwanas of India, is an extinct genus with large leathery leaves usually divided into five wedge-shaped segments, of which the middle one is the largest. Other extinct genera are *Dicranophyllum*, from the Carboniferous of France, China, and Canada; *Trichopitys*, from the Jurassic of Europe; the allied *Czekanowskia*, from the European Rhætic and Jurassic, the Jurassic of China, the Wealden of Portugal, and the Upper Gondwanas of India; and *Fieldenia* and *Phœnicopsis*, the former being from the Miocene of Spitzbergen, and the latter from the Jurassic of Northern Europe and the Upper Gondwanas. Many of these genera have the leaves divided into long slender slips, but in the true Yews the leaves are simply acicular. The existing genus *Taxus*, together with the closely allied or identical *Taxites*, has a wide distribution, being well represented in the Tertiaries and extending down through the Jurassic to the Rhætic. The allied *Cephalotaxus*, of China and Japan, in which the male flowers are in clusters, and the seed is completely enveloped in the fleshy capsule, is represented in the Tertiary and Cretaceous of Greenland; while another existing genus, *Torreya*, occurs in the Tertiaries of Greenland and America. Finally, omitting some less important types, the tropical genus *Podocarpus* occurs abundantly throughout the Tertiaries of the greater part of the world.

The genus *Walchia* (fig. 1402) may be taken as the representative of a group—the *Walchieæ*—which may perhaps serve to connect the Yews with the Araucarias. In the type genus the secondary branches or twigs are arranged alternately in two rows, and carry spirals of angulated acicular leaves; larger leaves covering the primary branches in an imbricating manner. The fruit, according to Dr Schenk, formed true cones, approximating to those of the

Araucarias; but it should be observed that Sir J. W. Dawson considers that their fruit was not in the shape of cones, but was of the type of that of the Yews. This genus occurs in the Permian of Europe and North America. *Ullmania*, of the European Permian and Keuper, is an apparently allied type in which cones are known to have been developed.

In the same family Dr Schenk places the genus *Pagiophyllum* (*Pachyphyllum*), which has thick leathery leaves of triangular form,

Fig. 1402.—Part of branch (*a*) and twig (*b*) of *Walchia piniformis*; from the Permian of Saxony. (After Gutbier.)

arranged spirally on the stem and branches, and uniting at their bases. In Europe it occurs from the Bunter to the Lower Cretaceous; it has also been recorded from the Upper Gondwanas of India, but some of the species from those beds seem to belong to *Araucaria*, to which this genus appears to be nearly related.

The *Araucarieæ* are too well known to require much description; typically they are lofty evergreen trees, with verticillate spreading branches, covered with stiff and flattened leaves, with sharp points, and usually imbricating. The cones are large, globular, and terminal. The existing species are mostly confined to the southern hemisphere, and belong to three genera. Of these, *Dammara*, which extends into the Malay Peninsula, and affords the well-known gum-damar, may be represented in the Upper Cretaceous of Greenland and the United States; but the specimens from the Cretaceous described as *Dammarites* may apparently be cones of Cycads. *Araucaria* itself is now chiefly known from Australia, New Guinea, Norfolk Island, and South America, but in past times had a much wider distribution. Thus it occurs in the Tertiary of the Arctic regions, in the English Eocene, in the Dakota stage of the American Cretaceous, and right through the Wealden and Jurassic of Europe. It also occurs in the Indian Gondwanas, where some of the species have been described as *Araucarites*, while the figured specimen (fig. 1403), which was referred by Dr Feistmantel to

Pagiophyllum, is regarded by Dr Schenk as inseparable from the existing genus. The extinct genus *Cunninghamites* is founded on branches which appear to closely resemble those of the existing *Cunninghamia* of China; it occurs in the Upper Cretaceous and Miocene of the Continent, and the Cretaceous of the United States. Finally, the genus *Albertia*, from the Bunter of Alsace and the Lower Gondwanas of India, may be mentioned here, although it is not certain that its true position is not with the *Abietineæ*.

Fig. 1403. — Branch of *Araucaria (Pagiophyllum) divaricata*; from the Upper Gondwanas of Cach. (After Feistmantel.)

The family *Taxodineæ* is another ancient type represented from the Permian upwards. The leaves are generally more or less linear, and may be arranged in two rows, or crowded together at the ends of the branches. In *Taxodium* and *Glyptostrobus* the lateral shoots are deciduous. The oldest genus is *Voltzia* (*Glyptolepis*, *Glyptolepidium*), of the Permian and Trias of Europe and the Lower Gondwanas of India; followed by the allied *Leptostrobus*, of the Lower Jurassic of Siberia. *Cyclopitys*, again, from the latter deposits and the Lower Gondwanas of India, is considered to be an ancestral type of the existing *Sciadopitys* of Japan, which connects the typical members of the family with the *Abietineæ*. The genus *Taxodium* is now known by two species from North America, of which *T. distichum* dates from the Upper division of the Laramie beds, and occurs also in the Eocene of Utah, whence it can be traced through the Tertiaries of Alaska, Canada, Greenland, and Spitzbergen, and thus to the Upper Miocene of Œningen in Switzerland. The closely allied *Glyptostrobus* of China, readily characterised by the sculptured scales of the cones and small leaves, has a somewhat analogous distributional history; thus it first appears in the Lower Cretaceous of Greenland, and is also found in the upper part of the same system; thence it extends in one direction through Arctic America to the United States, where it is found in the topmost beds of the Laramie, and in another to Europe, where its range extends from the Lower Miocene (Oligocene) to the Pliocene; *G. europæus* being common to Europe and the Laramie beds. The well-known *Sequoia* (*Wellingtonia*), in which the scales of the cones, instead of imbricating as in the preceding genera, form woody pyramids at right angles to the axis, is now known by two Californian species. Of these *S. sempervirens* has erect leaves arranged in two rows and small round cones; while *S. gigantea*, the "Big tree," has smaller leaves crowded together, and larger egg-shaped cones. It is remarkable that these two types are represented by allied species in the Lower Cretaceous, where we also find species which are intermediate, and both types continue right through the Tertiaries of Europe and North America, which are connected by the Greenland deposits; while one species has also been found in the Eocene of Australia. Altogether twenty-six species are known.

"This," as Sir J. W. Dawson observes, "is perhaps the most remarkable record in the whole history of vegetation. The Sequoias are the giants of the Conifers—the grandest representatives of the family—and the fact that, after spreading over the whole northern hemisphere and attaining to more than twenty specific forms, their decaying remnant should now be confined to one limited region in America, and to two species, constitutes a sad memento of departed greatness. The small remnant of *S. gigantea* still, however, towers above all competitors as eminently the 'big trees'; but had they and the allied species failed to escape the Tertiary continental submergences and the disasters of the glacial period this grand genus would have been to us an extinct type. In like manner the survival of the single Gingko of Eastern Asia alone enables us to understand that great series of taxine trees with fan-like leaves of which it is now the sole representative."

Geinitzia, from the Upper Cretaceous and Lower Tertiary of both Europe and North America, appears to connect the preceding with the following genus: it has alternating branches, with two rows of small sickle-shaped leaves, between which are scale-like leaves and elongated persistent cones. *Brachyphyllum* is characterised by its extremely short and thick scale-like leaves, which are spirally arranged; it occurs in Europe from the Rhætic to the Wealden, and is also found in the North American Cretaceous. An allied extinct genus is the remarkable *Echinostrobus*, of the Upper Jurassic of Europe and the Indian Upper Gondwanas, in which the stem is flattened, and the branches are covered with imbricating scale-like leaves; while the club-like cones are borne at the summits of short lateral branches. Other extinct genera of this family are *Cyparissidium* from the Rhætic and Upper Cretaceous of Europe; *Inolepis* of the Upper Cretaceous of Greenland; *Chirolepis* from the Rhætic and Lias of France and Switzerland; and *Swedenborgia* from the Rhætic of Palsjö.

The *Cupressineæ*, including the Cypresses, Junipers, and Thujas, are moderate sized or shrub-like trees, usually with very minute scale-like leaves closely adherent to the branches, and generally arranged in two, although sometimes in three or four rows. In some cases, however, the leaves are linear, especially in the young. This family dates from the Upper Trias, and is represented at the present day by some twelve genera. One of the earliest known genera is *Widdringtonites*, from the Keuper of the Continent and the

Jurassic of Europe and the United States; it appears to be in some respects intermediate between other Conifers and the next genus, and its reference to this family is provisional. The existing South African genus *Widdringtonia*, in which the leaves are alternate and crowded, and in the young plant linear, is represented in the Continental Miocene; while *Callitris* from the northern part of the same continent was likewise widely spread over Europe in the Middle Tertiary. In the Upper and Lower Cretaceous of Europe, and also in North America, we meet with the extinct genus *Frenelopsis;* while in the Tertiaries allied forms have been referred to the existing genera *Frenela* and *Actinostrobus*, now confined to the Australian region; *Librocedrus*, which has now a much wider distribution than the latter genera, dates from the higher Cretaceous of Greenland and the United States, and is well represented in the Lower and Upper Miocene of Europe. In *Moriconia* of the Upper Cretaceous of Greenland and Germany, and the Dakota Cretaceous of America, and *Thujites* ranging from the Rhætic[1] to the Upper Jurassic, we have two genera of which the precise affinities are difficult to determine. Of the remaining existing genera known to occur in a fossil state, *Thuja* is found in amber, and has also been recorded from the Upper Cretaceous and Miocene of North America, but these forms are regarded by Dr Schenk as probably referable to *Chamæocypris*. *Biota* of Japan and China, and *Thujopsis* of Japan, occur in the Miocene of Greenland; *Chamæocypris*, of North America and Japan, dates from the Lower Eocene and Miocene of Europe, and probably from the American Cretaceous; *Cupressus* (Cypress), which has a wide distribution in the northern hemisphere, is probably found in amber; while *Juniperus* (Juniper) dates from the Upper Cretaceous of America and Greenland. Finally, *Palæocyparis* which occurs throughout the European Jurassic, and *Phyllostrobus* of the Kimeridgian of France, are allied extinct types. The last family of Conifers is the *Abietineæ*, including the Pines, Spruces, Larches, and Cedars, all of which have tall symmetrical stems, and usually spirally-arranged linear leaves, which may be either flattened or angulated. The cones are usually large and pyriform, with two seeds beneath each scale. We may first mention the extinct genera *Elatides* and *Palissya*, of which the family position is uncertain, since they show some characters of the Pines and others of the Yews. The former occurs in the Jurassic of Siberia, but some of the forms appear to be *Araucarieæ;* while the latter is found in the European Rhætic, the Lower Gondwanas of India, the Australian Newcastle beds, and the reputed Trias of New Zealand. The existing types are usually divided into a number of genera, such as *Pinus* (true Pines), *Abies* (Spruce),

[1] The form from the Carboniferous described under this name is probably a Lepidodendroid.

Larix (Larch), *Cedrus* (Cedar), &c., but the generic determination of many fossil types is extremely difficult, and we can only state here that the group as a whole has undoubtedly existed from the Jurassic, and may not improbably date from the Lias or Rhætic. Finally, the family position of the imperfectly known Rhætic genus *Camptophyllum* cannot at present be determined.

ORDER 3. GNETACEÆ.—This small order, represented by the genera *Ephedra*, *Gnetum*, and *Welwitschia*, is not certainly known to be represented in a fossil state, although several forms have been referred to the first-named genus.

CHAPTER LXVIII.

SERIES PHANEROGAMÆ—continued.

CLASS ANGIOSPERMÆ.

CLASS II. ANGIOSPERMÆ.—With this class we come to the highest development of plant life, characterised by the complete enclosure of the ovules and seeds in the ovary, and by the more or less rudimental condition of the endosperm. As they are highest in point of development, so these plants are characteristic, as a whole, of the latter periods of the earth's history, so that the Tertiary and recent periods are well described as the "age of Angiosperms." The class may be divided into the two great subclasses of Monocotyledons and Dicotyledons, of which the former is the more generalised, and the first to make its appearance in time.

SUBCLASS I. MONOCOTYLÆ.—The Monocotyledons are plants having only a single seed-leaf or *cotyledon;* and with an endogenous, or inwardly growing stem, in which there are consequently no annual rings of growth. It includes the Palms, Grasses, Lilies, &c.; and it appears that the Palms and Grasses are the earliest known forms; the perianthed types, or those with large and conspicuous flowers, not making their appearance till a later date.

There is indeed some doubt as to the earliest appearance of the subclass, but it appears to be certain that most of the Palæozoic forms which have been described as Monocotyledons are referable to Gymnosperms. There occur, however, certain forms of doubtful affinity in the Upper Palæozoic, which have been termed "pro-Angiosperms," or types imperfectly developed from a Pteridophytic or Gymnospermic stock, which we may proceed to notice. The best known is the genus *Spirangium*, ranging from the Carboniferous to the Wealden; this is based on certain spindle-like bodies, which are believed to consist of from five to ten linear valves enclosing a central cavity, the valves being in some cases spirally twisted. Their affinities are at present totally obscure. From the Russian Permian a leaf with a net-like venation described under the name of *Dichoneuron*, has been regarded as a Monocotyledon, but apparently on quite insufficient grounds. The genus *Œthophallum*, from the Trias of the Vosges, which has linear leaves arranged in groups of three on the branches of a woody stem, and long seed-bearing spikes, has also been referred to this subclass. Certain fruit-spikes from the same deposits described as *Echinostachys* may belong to kindred types. Again, the long ribbon-like leaves found in the Rhætic and Jurassic and known as *Yuccites*, have been looked upon as indicating plants allied to the existing *Dracæna ;* but it is quite possible that remains of totally distinct types of vegetation have been included under this name. In the Upper Trias and Lias of Switzerland occurs the imperfectly known *Bambusium*, which Mr J. S. Gardner regards as an undoubted Monocotyledon, although Dr Schenk suggests affinity with the Equisetaceæ. The former writer also regards as Monocotyledonous a stem from the Yorkshire Oolites described as a Calamite. Plants from the Jurassic which have been named *Naiadita*, *Bensonia*, &c., are not Phanerogams at all; while *Aröides* of the Great Oolite is based on a Crinoid. Stems with a rush or grass-like form from the Purbeck appear, however, to be true Monocotyledons. Finally, *Rhizocaulon*, from the Upper Eocene of the Paris basin, is based on the evidence of a stem which may indicate a plant allied to the *Cyperaceæ*.

Leaving these doubtful types, we may proceed to the consideration of Monocotyledons which can be systematically placed.

ORDER I. LILIIFLORÆ.—This order includes the Lilies, Irises, Yuccas, and their allies, most of which have conspicuous perianthed flowers, which vary considerably in structure, and may be of large size. The plants may be perennial, but are more usually annual, with rhizomes or bulbs. The *Liliaceæ* (Lilies, Tulips, Aloes, Yuccas, &c.) are but of little palæontological importance. From the Eocene and higher Tertiaries plants have been described under the names of *Agavites*, *Yucca*, and *Dracæna*, the two last being existing genera; but Dr Schenk considers that most of these belong to *Dracæna* (Dragon-tree), now found in the Canaries, Africa, and India. Plants of the genus *Smilax*—the type of a subfamily of *Liliaceæ*—occur in the European Tertiaries from the Eocene upwards; although it seems doubtful if forms described as *Smilacina* and *Majanthemophyllum* really belong to this group. The *Juncaceæ*, or Rush family, are known by species of *Juncus* from the Upper Miocene of Œningen; and, according to Dr Schenk, a species of *Iris* from the same deposits is the only fossil representative of the *Iridaceæ*, although several other fossils have been described under that name. In the *Dioscoreaceæ* (Yams), *Dioscorites*, from the European Miocene, is probably allied to *Dioscorea ;* while in the Pine-apple family, or

Bromeliaceæ, the typical *Bromelia* apparently occurs in the same deposits. Other fossils referred to these families are, however, distinct.

ORDER 2. ENANTIOBLASTÆ.—There is some uncertainty as to whether this small order is represented in a fossil condition, but it is not improbable that *Eriocaulon* occurs in the Tertiary of the United States.

ORDER 3. SPADICIFLORÆ.—With this order, which comprises the Palms, Screw-pines, and Arums, we come to one of considerable palæontological importance, as including several of the earliest representatives of the class. They are typically tall plants, with large wide-spreading leaves, and the inflorescence forming a spadix, generally enveloped in a large spathe, and without a petalled perianth; the seed being generally large, and often of huge size. The first family of the *Palmaceæ* now includes about one thousand species from the warmer regions of the globe, and dates back to the Upper Cretaceous. In the higher Cretaceous of Europe we meet with Palms referred to the extinct genus *Flabellaria*, which also ranges into the Miocene, and has been recorded from the Cretaceous of the United States. *Fasciculites*, from the Cretaceous of Greenland, is regarded

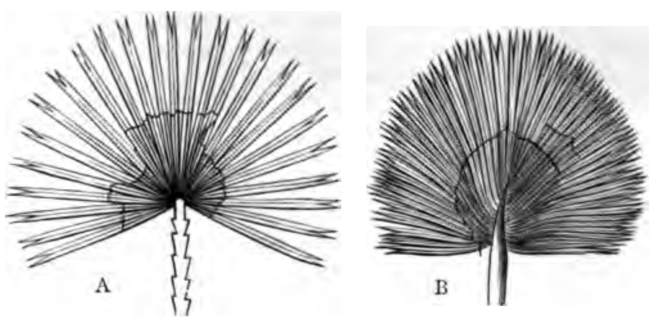

Fig. 1404.—A, Leaf of *Chamærops helvetica*; from the Upper Miocene of Switzerland. B, Leaf of *Sabal major*; from the Lower Miocene of France. Reduced.

with some hesitation as a Palm-stem; and Mr Gardner figures Palm-wood from the Folkestone Gault; but many other earlier fossils, such as *Palæospathe*, are not Palms at all. In the Tertiary Palms are abundant, and from the Eocene to the Upper Miocene we meet with forms with pinnate leaves allied to the existing *Phœnix* (Date-palm), which have been described under that name, or as *Phœnicites* and *Calamopsis*. Of the group with fan-like leaves we have already mentioned *Flabellaria*, and throughout the European Tertiary there occur leaves referred to the Old World genus *Chamærops* and to *Sabal* of North America (fig. 1404); both of which genera have a more northerly distribution than any other types. *Sabal* *major* (fig. 1404) occurs in the Lower and Middle Miocene of Europe, and also in the Miocene of Northern India; while remains of the same genus have been described from the Tertiary of the United States. In the Lower Eocene of Europe and the Chalk of Fuveau large fruits occur known as *Nipadites* (fig. 1405), from their resemblance to the triangular fruits of the Oriental and Australasian genus *Nipa*, which some writers class with the Palms and others with the *Pandanaceæ*. There is considerable doubt whether the small family *Cyclanthaceæ*, of tropical America, is represented in a fossil state, but fragmentary leaves from the Lower Eocene of Sézanne have been described as *Ludoviopsis*, from their supposed resemblance to those of *Ludovica*. The well-known *Pandanaceæ*, or Screw-pines, are trees or shrubs with long simple imbricated leaves, usually spined on the edges and back, and unisexual or polygamous flowers, without perianth, and covering the whole of the spadix; the fruit being in the form of drupes with single seeds, or berries with numerous seeds. All the living forms are tropical. Leaves from the Tertiary and Upper Cretaceous of Europe have been referred to *Pandanus;* but it is a question whether at least some of these do not indicate a distinct genus. In the Cretaceous and Jurassic of Europe, extending as far north as Greenland, there occur fruits to which the name *Kaidacarpum*[1] has been applied, and which are regarded by their describer, Mr Carruthers, as undoubtedly Pandanaceous, although Dr Schenk is not absolutely satisfied of the correctness of this reference. The fruit consists of a thick spadix, with bunches of drupes, each of which contains a single seed; the whole arrangement being strikingly like that of the existing *Sussea*. *Podocarya* is an apparently allied fruit from the Inferior Oolite; and some authorities regard *Williamsonia* (p. 1528) as related to this genus. *Goniolina*, from the Kimeridgian and Corallian of France, is founded on compound fruits which are compared by Mr Gardner to those of *Pandanus*, and of which the description is as follows:—

Fig. 1405.—Fruit of *Nipadites ellipticus*; from the London Clay. Reduced.

"Small ovoid aggregated fruits, like those of *Pandanus*, borne on a naked, cylindrical, and relatively slender petiole. The heads of the very numerous fruits are arranged in spirals and regular, pressed together, and barely a millimetre across. They are of hexagonal shape, and six keels extend from the angles and meet in a raised point at the centre. The interior axis is cylindrical, and impressed by scars made by the bases of the fruits, completing its likeness to *Pandanus*."

[1] Correctly *Cædacarpum*.

The reed-like plants of the family *Typhaceæ* occur throughout the Tertiary, where we have *Typha* (Reed-mace) or the allied *Typhæo-loipum*, and *Sparganium*, although it is doubtful if the Cretaceous plants referred to these genera are rightly named. The *Araceæ* (Arums and their allies) appear to date from the Upper Cretaceous, although it is extremely uncertain if the Tertiary plants described as *Aröites* and *Aronites* really belong to this family. *Acorus* (Sweet-flag) occurs in the Miocene of Spitzbergen, and is also found in amber; and *Pistia*, a tropical water-weed allied to the common

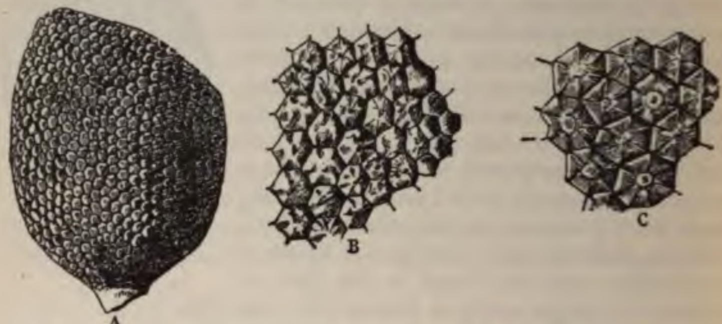

Fig. 1406.—A, Fruiting-organ of *Goniolina;* B and C, The individual fruits enlarged; from the Kimeridge Clay of France. (After Saporta and Marion.)

Duck-weed (*Lemna*), occurs in the Laramie beds of America and the Upper Cretaceous of the Continent; but the plants from the Westphalian Chalk and the Laramie beds, described as *Pistites* and *Lemnophyllum*, according to Dr Schenk, are not Monocotyledons. *Lemna* has been described from the Laramie and Middle Tertiary of North America, and also from the Miocene of Würtemberg. *Pothocites*, of the Carboniferous, which has been referred to this family, is part of a Sigillarian. In the aquatic *Naiadaceæ* we have remains of the fluviatile genera *Posidonia* and the marine *Zostera* (*Zosterites*) dating from the Upper Cretaceous of both the eastern and western hemispheres. *Cymodocea* may also date back to the Eocene, although many of the forms described under its synonym of *Caulinites* are totally different. *Naias* occurs certainly in the Miocene of Œningen, and perhaps in lower beds; while *Potamogeton* (Pond-weed), with its dimorphic leaves, dates from the Upper Eocene of Aix, and is also found in the Tertiaries of North America.

ORDER 4. GLUMIFLORÆ. — This order includes the Grasses, Sedges, &c., and is of but little importance to the palæontologist. In the *Gramineæ*, exclusive of some very doubtful forms, we may notice that *Bambusa* (Bamboo) occurs in the Pliocene of Europe;

but that the so-called *Bambusium* is probably Equisetaceous. *Arundo* and the allied *Phragmites* are stated to make their first appearance in the Upper Cretaceous of both hemispheres; while *Pseudophragmites* and *Arundites*, dating from the Eocene, are more or less closely allied extinct types. In the *Cyperaceæ* (Sedges) numerous fossil Tertiary plants have been described as *Carex*, *Cyperus*, *Cyperites*, and *Scirpus*, the former being also recorded from the Laramie; but all these determinations are exceedingly doubtful, and it can only be stated with certainty that *Cyperus* occurs in the Œningen Miocene.

ORDER 5. SCITAMINEÆ.—The past history of this large tropical order is even more imperfect than that of the last. In the *Musaceæ* (Plantain) large leaves, from the Eocene and higher Tertiaries, have been described under the names of *Musaphyllum* or *Musa*, but Dr Schenk suggests that some at least of these may belong to the *Araceæ*. Under the name of *Zingiberites* imperfect leaves, from the Upper Cretaceous of Greenland and the Swiss Tertiary, have been regarded as indicating fossil *Zingiberaceæ;* and a similar position has been given to *Amomocarpum* and *Amomophyllum* of the Upper Eocene of Paris. Finally, *Cannophyllites*, of the latter beds, has been considered as an ally of the existing *Canna* among the *Marantaceæ*.

ORDER 6. GYNANDRÆ.—The only fossils hitherto referred to the Orchids are the *Protorchis* and *Palæorchis*, of the Middle Eocene of Monte Bolca; and it is probable that the greater number of these plants, with their highly specialised and complexly perianthed flowers, are of comparatively recent origin.

ORDER 7. HELOBIÆ.—The last order comprises aquatic and marsh plants which date back to the Upper Cretaceous. *Laharpia*, from the Miocene of Œningen, may perhaps indicate a member of the *Jungaginaceæ* allied to the existing *Scheuchzeria*. In the *Alismaceæ* some of the forms, occurring from the Cretaceous upwards, referred to *Alisma* and *Sagittaria*, may be correctly named. *Butomus* has been recorded from the Miocene of Œningen. Of the *Hydrocharitaceæ*, *Stratiotes* and *Hydrocharis* have been described from Œningen, and the extinct *Hydrocharites* from the Miocene of Bonn; while *Valisneria* and *Ottelia* date from the Upper Eocene of the Paris basin in Europe, but the former also occurs in the Laramie of America, and thus carries back its origin to the Cretaceous.

SUBCLASS II. DICOTYLÆ.—The Dicotyledons are plants having two cotyledons or seed-leaves, and the stems exogenous like those of the Gymnosperms. They represent the highest type of plant-life, their organisation being a great step in advance of the Monocotyledons. The earliest known members of this group occur in the reputed Lower Cretaceous of Greenland, where, however, only a few forms are known; but when we come to the Dakota stage of the United States, which is usually correlated with the lower part of the Upper Cretaceous of Europe, Dicotyledons formed a large proportion of the flora, more than three hundred species having been described in 1885, which belong to both sections of the subclass. This abundance of forms pointing to the conclusion that the origin of Dicotyledons must be looked for in considerably earlier epochs.

Very different views are held by authorities as to the classification of Dicotyledons, some dividing them into several primary groups, while others only admit the three divisions Apetalæ, Polypetalæ, and Gamopetalæ. Dr Endlicher, however, makes only two divisions—Choripetalæ and Sympetalæ,—and since this arrangement is adopted by Dr Schenk in his 'Palæophytologie,' it will be followed in this work.

The larger proportion of the Cretaceous and Eocene Dicotyledons belong to the Choripetalæ, and especially to those orders in which the flowers are fertilised merely by the agency of the wind; the more specialised Sympetalæ, which require the aid of insects for this purpose being in great part of later date. The labours of Baron von Ettingshausen have shown that the Cretaceous and early Tertiary Dicotyledonous (and also the Monocotyledonous and Gymnospermous) flora was almost similar throughout the world; and that its present division into provinces is in great part due to the influence of one or more glacial periods. Bearing in mind this worldwide distribution of so many of the genera, it will be unnecessary in most cases to do more than mention their earliest established occurrence; and owing to the immense number of families only the more important types can be even mentioned at all. Space will not permit any reference to the gradual differentiation of the existing floras, or to the interesting distribution of modern arctic types in the Pleistocene, for which the reader must refer to the works of Baron von Ettingshausen, Sir J. W. Dawson, and other writers. It should be mentioned that in the case of trees known only by the leaves the generic determination may be open to doubt in some cases.

DIVISION A. CHORIPETALÆ.—This large group is characterised by the petals being either absent, or if present not united together.

ORDER I. AMENTACEÆ.—This order comprises trees which are typically apetalous with the male flowers in the form of catkins. It includes five families, and comprises some of the earliest known representatives of the subclass. The first family, *Casuarinidæ*, is now represented only by the well-known *Casuarina* of the Australian and the eastern Malayan regions: this genus apparently occurs in the Lower Tertiary of Sumatra, but it is very improbable that the European fossils described under this name are really referable to the group. With the *Cupuliferæ*, containing the Alders, Birches, Hazels, Beeches, Oaks, &c., we come to a large group well represented in a fossil state, many of the forms being known by the seeds as well as the leaves. The existing genera *Alnus* (Alder), and *Betula* (Birch), are recorded from the Laramie and Dakota stages of the Upper

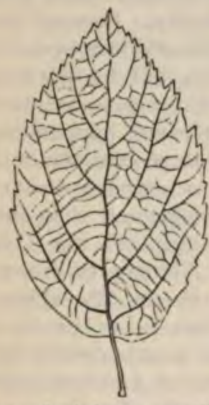

Fig. 1407.—Leaf of *Alnus gracilis*; from the Miocene of Europe. (After Unger.)

Fig. 1408.—Leaf of *Betula cuspidens*, and fruit of *B. dryadum*; from the Lower Miocene of Europe. Reduced. (After Saporta and Brongniart.)

Cretaceous of the United States, and likewise from the Cretaceous of Greenland, but Dr Schenk suggests some doubt as to whether these forms really belong to the living genera, and would prefer to call them *Alnophyllum* and *Betulophyllum*. An allied Cretaceous form has been named *Alnites*. In the Tertiary the existing genera (figs. 1407, 1408) are well represented from the Eocene upwards. In the next subgroup *Corylus* (Hazel), *Ostrya*, and *Carpinus* (Horn-

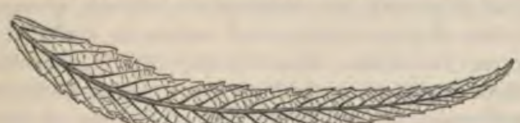

Fig. 1409.—Leaf of *Dryophyllum*; from the Lower Eocene of Europe. Reduced. (After Saporta.)

beam) also occur from the Eocene, while the former is recorded from the Laramie. *Fagus* (Beech) dates from the Dakota stage, which has also yielded remains referred to *Castanea* (Chestnut); and *Castanopsis* has been recorded from the American Eocene, and the Australian Tertiary, although it is suggested that some of the forms so named may belong to *Dryophyllum*. The latter name is applied to elongated leaves (fig. 1409), from the Upper Cretaceous and Eocene of both Europe and North America, which appear to be in some respects intermediate between those of *Castanopsis* and the earlier species of Oaks. The leaves of *Quercus* (Oak) are subject to an enormous amount of variation, rendering the determination of fossil forms a work of extraordinary difficulty. One of the most ordinary and characteristic types of leaf is shown in fig. 1410, but in the early Tertiary and Upper Cretaceous we meet with long slender oak-leaves approximating to those of *Castanea* in general contour. The earliest recorded occurrence of the genus is in the Dakota stage, and it is abundantly represented throughout the Tertiaries; leaves, from the Tertiary of Australia, in which country oaks are now absent, have been described as *Quercus*, but doubt has been thrown on this determination. In the *Juglandaceæ*, the genus *Juglans* (Walnut) probably dates from the Upper Cretaceous of America and Greenland; the Tertiary species of which a leaf is figured in the woodcut occurs on both sides of the Atlantic, and appears to be closely allied to the existing *J. regia*. The name *Juglandites* has been applied to leaves from the Upper Cretaceous and Eocene of Europe, which are believed to indicate an allied type. *Carya* (Hickory), now confined to America, is recorded from the Cretaceous of that country, and occurs in both the European and American Tertiaries. Similarly the Old World *Pterocarya* is represented in the Tertiaries of both hemispheres, while the Oriental genus *Engelhardtia* occurs in the Upper Eocene of Aix, where it has been described as *Palæocarya*. In the *Myricaceæ* the single genus *Myrica* makes its first appearance in the Upper Cretaceous of Greenland and North America, and is common in the Tertiaries. Of more palæontological importance is the family *Salicaceæ*, in which both *Populus* (Poplar) and *Salix* (Willow), (fig. 1415, *d*), date from the Upper Cretaceous. A leaf from beds at Komi in Greenland, which have been regarded as Lower Cretaceous, has, indeed, been described as *Populus*, but according to Mr J. S. Gardner on totally insufficient grounds; but Sir J. W. Dawson considers that *Salix*

Fig. 1410.—Leaf of *Quercus conferta*. Recent. Reduced. (After Schenk.)

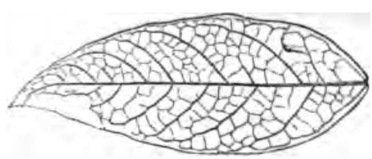

Fig. 1411.—Leaf of *Juglans acuminata*; from the Miocene of Europe. Reduced. (After Schenk.)

may occur in the Lower Cretaceous of the United States. The species of *Populus* of which a leaf is figured in the woodcut extends from the Lower Miocene to the Pliocene.

Fig. 1412.—Leaf of *Populus latior*: from the Miocene of Europe. Reduced. (After Schenk.)

ORDER 2. URTICINÆ.—This order contains the three families *Ulmaceæ*, *Urticaceæ*, and *Ceratophyleæ*; the last of which requires no further mention. In the first family *Ulmus* (Elm) makes its first undoubted appearance in the Upper Eocene (Lower Oligocene) of Aix, in Provence, but the Asiatic and American *Planera* dates from the Laramie Cretaceous, and is common in the European Tertiary. *Celtis* (Nettle-tree), now abundant in southern Europe, is well represented throughout the Continental Miocene; while *Morus* (Mulberry) is unknown before the Upper Miocene. The tropical *Artocarpus* (Bread-fruit) dates from the Upper Cretaceous of Greenland, and also occurs in the Œningen Miocene; and it is probable that some of the forms from the Lower Eocene and Miocene of Europe described under the names *Artiocarpidium* and *Artiocarpoides* are allied types, although others belong to *Ficus*. The latter genus includes the numerous species of Fig mostly characteristic of the warmer regions; it dates from the Greenland Cretaceous and the Laramie, and is abundant in the Tertiaries of many parts of the globe. The names *Ficonium* and *Protoficus* have been applied to fig-like leaves from the Eocene, some of which may belong to this family. In the *Urticaceæ* it has been considered that *Urtica* (Nettle) occurs in the Middle Miocene of Styria, but this requires confirmation. That the family occurred in the Tertiary is, however, proved by the genus *Forskohleanthemum*, which is found in amber, and is allied to the existing tropical and subtropical genus *Forskohlea*. Here may be mentioned certain genera of uncertain affinity which are considered by Dr Schenk to be allied to the *Urticaceæ*, although Sir J. W. Dawson would place them near the *Platanaceæ*; these comprise the Upper Cretaceous *Credneria* and *Ettingshausia* from Europe; *Macclintockia*, with more elongated leaves, from both the Cretaceous and Eocene; and *Protophyllum* of the American Cretaceous, which is considered by Dr Schenk to be allied to the existing Urticaceous genus *Laportea*.

ORDER 3. PIPERINEÆ.—In this group *Piper* (Pepper) and allied forms described as *Piperites* occur in the Lower Tertiary of Java and Sumatra; the existing forms being now tropical.

ORDER 4. CENTROSPERMÆ.—This large order, which includes the

Pinks and Portulacas, is very sparingly represented in a fossil state, but we may mention that *Polygonum*, *Coccolabis*, and *Salsola* occur in the European Miocene; while *Pisonia* is found in the Middle Tertiaries of both Europe and North America.

ORDER 5. POLYCARPIEÆ.—Of the nine families constituting this order only the *Lauraceæ*, *Nymphæaceæ*, and *Magnoliaceæ* are of much importance to the palæontologist. In the *Lauraceæ* the existing genera *Laurus* (Laurel), *Sassafras* (fig. 1415, *a*) *Cinnamomum* (Cinnamon, fig. 1413), *Persea* (Alligator-pear, fig. 1414), and *Oreodaphne*, occur in the Upper Cretaceous of Europe or the United States, and throughout the greater part of the Tertiaries. With the exception of *Laurus* all these genera are now tropical or subtropical, *Persea* and *Oreodaphne* being restricted to America; and their abundance in the European Tertiaries affords conclusive proof of the warm climate of that epoch. *Cinnamomum* also occurs in the Tertiary of Australia, and *Litsæa* in that of Borneo. In the *Berberidaceæ* the type genus *Berberis* (Berberry) dates from the Lower Miocene; but with the *Menispermaceæ* we return to a family dating from the Cretaceous, where it is represented in the United States by the extinct *Menispermites*. *Cocculus*, of the Oriental region, is found in the European Pliocene, and has also been recorded from the Eocene, but the latter determination is doubtful. Leaving out some other unimportant types we may pass to the family *Magnoliaceæ*, which has a palæontological history of considerable interest. The type genus *Magnolia*, so well known for its magnificent white flowers, is now confined to Asia and North America, but in the Tertiary was spread over all Europe, and has also been recorded from Australia; its earliest appearance being in the Upper Cretaceous of France and the United States. The other well-known genus is *Liriodendron*, now represented only by the handsome Tulip-tree (*L. tulipifera*) of eastern America, but in former times having a wide distribution, and dating from the Cretaceous of

Fig. 1413.—*Cinnamomum polymorphum*. *a*, Leaf; *b*, Flower; from the Upper Miocene of Europe. Reduced.

Fig. 1414.—Leaf of *Persea princeps*; from the Upper Miocene of Switzerland. Reduced. (After Heer.)

both hemispheres. The leaves (fig. 1415, *b*) are readily recognised by their lyre-like form and deep terminal emargination.

The observations of Dr Newberry on this genus are so interesting that, with some omissions and verbal alterations, they may be quoted at length. The doctor observes, "that a plant so splendid should stand alone in the vegetation of the present day excited the wonder of the earlier botanists, but the Sassafras, Sweet-gum, and the Sequoias of the West afford similar examples of isolation. Three species of *Liriodendron* occur in the Cretaceous of New Jersey, and others have been obtained from the Dakota group in the West, and from the Upper Cretaceous of

Fig. 1415.—Leaves of American Cretaceous Dicotyledons. *a*, *Sassafras cretaceum*; *b*, *Liriodendron Meeki*; *c*, *Leguminosites Marcouanus*; *d*, *Salix Meeki*. (After Dana and Lesquereux.)

Greenland. Though differing considerably among themselves in size and form, all these have the deep sinus of the upper extremity of the leaves so characteristic of the genus, and the venation is also essentially the same. Hence we must conclude that the genus, now represented by a single species, was in the Cretaceous age much more largely developed, having many species, and those scattered over many lands. In the Tertiary the genus continued to exist, but the species seem to have been reduced to one, which is hardly to be distinguished from that now living. In many parts of Europe leaves of the tulip-tree have been found, and it extended as far south as Italy. Three European species have, indeed, been described, but they are all so like the living form that they should probably be united with it. We here have a striking illustration of the wide distribution of a species which has retained its characters both of fruit and leaf quite unchanged through long migrations and an enormous lapse of time. In Europe the tulip-tree, like many of its American associates, seems to have been destroyed by the cold of the glacial period, the Mediterranean cutting off its retreat; but in America it migrated southward, and returned northward with the amelioration of the climate."

The mainly tropical family of the *Anonaceæ* includes trees and shrubs closely allied to the Magnolias, and the existing American and Malayan genus *Anona* is represented in the Upper Cretaceous and Tertiary of the United States, while in Europe it is found from the Eocene to the Pliocene. The extra-tropical North American genus *Asimina* occurs in the Laramie and Eocene of the same regions. The large family of the *Ranunculaceæ* is sparingly represented in a fossil state; thus *Clematis* has been recorded from the reputed Pliocene of Japan, the Miocene of Œningen, and the Eocene of Croatia, but it is not absolutely certain that the determination is correct. The same remark applies to other Tertiary plants referred to *Ranunculus* and *Helleborus* (*Helleborites*). The names *Dewalquea* and *Debea* have been applied to Upper Cretaceous plants considered to belong to this family, although Dr Schenk suggests affinity with the *Aroideæ*. The Water-lilies of the family *Nymphæaceæ* date from the Upper Cretaceous, where we meet with remains of the existing genus *Nelumbium*, succeeded in the Upper Eocene (Oligocene) by *Nymphæa* (fig. 1416). Seeds from the Miocene of Germany, described as *Holopleura*, are considered to be allied to those of the celebrated *Victoria*, of the African lakes. Other Tertiary types have been referred to extinct genera under the names of *Anæctomeria*, *Nymphæites*, and *Carpolithes*. Finally, the genus *Nuphar* is unknown before the Norfolk Forest-bed, where we meet with the existing Yellow Water-lily.

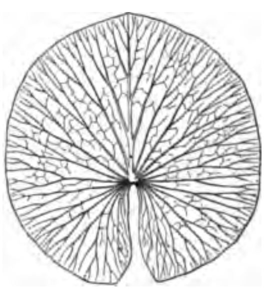

Fig. 1416.—Under surface of a leaf of *Nelumbium Dumasi*; from the Upper Eocene of France. One-eighth natural size. (After Saporta.)

ORDER 6. RHOEDINÆ.—Of the *Papaveraceæ* (Poppies) and *Cruciferæ*, constituting this order, the palæontological history is almost a blank, although a few Miocene forms have been referred to them. The *Cruciferæ* include the Cabbage tribe.

ORDER 7. CISTIFLORÆ.—This order is of somewhat more palæontological importance. In the *Violaceæ* (Violets and Pansies), *Anchietea* is recorded from the Miocene of Auvergne; while in the

Cistaceæ (Rock-roses) a *Cistus* has been described from that of Germany. A *Kiggelaria*, from the Upper Eocene of Saxony, is the only fossil representative of the *Bixaceæ*. The tropical family *Ternstræmiaceæ* is somewhat better known; thus we find *Pentaphylax* in amber of middle Tertiary age, while *Stuartia* also occurs in amber as well as in Pliocene beds. The genera *Ternstræmia*, *Freziera*, and *Sauruja* are known as fossils only by their leaves; the first dating from the Cretaceous of Bohemia, the second from the Eocene, and the third from the Miocene. Another tropical family, the *Dipterocarpeæ*, is represented in the Eocene of Sumatra and Borneo by species of the genus *Dipterocarpus*, now inhabiting the same regions, and yielding the balsam of Copaiba.

ORDER 8. COLUMNIFERÆ.—This order includes the four families *Tiliaceæ*, *Sterculiaceæ*, *Malvaceæ*, and *Bombaceæ*. In the first the existing genera *Tilia* (Lime), *Grewia*, and *Elæocarpus* occur fossil, the former dating from the Laramie, and the two latter from the Upper Eocene or Lower Miocene. Of extinct genera we may mention the Cretaceous and Lower Eocene *Grewiopsis* and *Apeibopsis*; the former being known by leaves, and the latter by gourd-like fruits, of very common occurrence in the London Clay, which resemble those of the existing American genus *Apeiba*. *Nordenskiældia* is based on allied fruits from the Tertiary of Spitzbergen. The *Sterculiaceæ* is an exclusively tropical family of trees and shrubs, in which the existing genus *Sterculia* commences in the Dakota Cretaceous, and continues right through the European Tertiaries. Extinct genera are *Dombeyopsis*, *Pterospermites*, and *Fracastella*, all of which commence in the Cretaceous, and continue to the Lower or Middle Tertiary. The leaves of *Dombeyopsis* (fig. 1417) are acutely trilobate, with numerous veins. The *Malvaceæ* and *Bombaceæ* have left but little record of their past history; but *Bombax* occurs in the Upper Eocene of Europe.

Fig. 1417.—Under surface of a leaf of *Dombeyopsis Decheni*; from the Lower Miocene of Germany. One-fourth natural size. (After Schenk.)

ORDER 9. GRUINALES.—The palæontology of this order, which includes Geraniums, Tropæolums, Sorels, Flax, and Balsams, may be summed up in very few words. It is thought that *Geranium* may occur in amber; the Tertiary *Oxalidites* is referred to the *Oxalidaceæ*; but the Tertiary fruit described as *Linum* (flax) is of very doubtful value as evidence of the family *Linaceæ*.

ORDER 10. TEREBINTHINÆ.—Of the families constituting this order, several are very imperfectly known before the present epoch. In the *Rutaceæ* (Rue-worts) the genus *Xanthoxylon*, which is now mainly tropical, occurs in the Upper Eocene and Lower Miocene of Europe, and also in the North American Tertiaries. *Ptelea* appears at the same date, but persists to the close of the Miocene period. With regard to *Protamyris*, from the Tertiary of Croatia, which was described as being allied to the existing *Amyris*, there is considerable doubt whether it really belongs to this family at all. In the *Simarubaceæ* the Indian and Chinese genus *Ailanthus* was formerly more widely spread, being found in Europe from the Upper Eocene to the Upper Miocene. There is some doubt whether the plants from the Middle Eocene of Monte Bolca, referred to the genus *Guajacites*, are really representatives of the American family *Zygophyllaceæ*. The large family of the *Anacardiaceæ*, typically represented by the tropical *Anacardium* (Cashew-tree), is known by a considerable number of fossil forms, although there is some doubt as to whether several of these are rightly determined. From the Upper Eocene of Provence a fruit has been referred to this family under the name of *Trilobium*. *Pistachia* (Pistachio), now distributed over the temperate zone of the northern hemisphere, is known from the European Upper Eocene and Miocene; while the name *Anacardites* has been given to leaves occurring from the Cretaceous to the Miocene. A large number of species, dating from the Upper Cretaceous and continuing through the Tertiaries of both Europe and America, have been referred to *Rhus* (Sumach), but it is probable that some of these belong to other plants. Of the other families, it will suffice to say that in the *Coriariaceæ* the genus *Coriaria* occurs from the Lower Miocene to the Pliocene of Europe.

ORDER 11. ÆSCULINÆ.—In this order the family *Sapindaceæ*, with the exception of *Kœlreuteria*, *Staphylea*, and *Æsculus*, is now confined to the tropics, and includes trees of large size. Fruits from the London Clay termed *Cupanoides*, and others from the Miocene of Croatia described as *Cupanites*, are believed to have belonged to sapindaceous trees allied to *Cupania*. *Paullinia* has been recorded from the Middle Tertiaries of the Continent, while *Kœlreuteria* occurs in the Upper Miocene. Fruits from the Tertiary of Eubæa have been referred to *Nephelium*, while an imperfect leaf from Borneo probably belongs to the same genus. *Sapindus*, which in America does not range north of Texas, is abundantly represented in the Upper Cretaceous and Tertiaries of both the Old and New Worlds. *Æsculus* (Horse-chestnut) has been recorded from the Laramie beds, but in Europe appears to be unknown before the Lower Miocene, although said to be abundant in the earlier Tertiaries of Japan. *Dodonæa*, now mainly confined to the southern hemispheres, is found in the Tertiaries of Europe and North America. Again, *Staphylea*, which is unknown as a fossil in Europe, is abundant in the Eocene of the United States. The genus *Acer* (Maple and Sycamore), now widely distributed, is represented by a great number of fossil species ranging from the Laramie stage upwards. The leaves are subject to great variation in form, the most remarkable types occurring in the Pliocene *A. polymorpha*; the woodcut shows a leaf of the more ordinary form together with one of the characteristic winged seeds.

Fig. 1418.—Leaf and seed of *Acer acutilobata*; from the Miocene of Germany. One-third natural size. (After Schenk.)

The mainly tropical family *Malpighiaceæ* is represented in the Tertiary from the Upper Eocene to the higher Miocene by several existing genera, such as *Stigmaphyllum*, *Banisteria*, *Tetrapteris*, and *Hiræa*, together with the extinct *Malpighiastrum*, ranging from the Eocene to the Upper Miocene or Pliocene; the whole of the above-mentioned existing genera being now confined to America.

In this place we may mention the family *Platanaceæ* which is placed by some writers in the Amentaceæ or Urticinæ, but of which the ovary and the general appearance of the trees bring it near to the Maples and Sycamores. Of the single genus *Platanus* (fig. 1419) there is now one species in Asia Minor and another in North America; fossil forms occurring as low down as the Dakota Cretaceous and continuing through the Tertiaries of both hemispheres, their last appearance in Europe being in the Œningen Miocene.

Fig. 1419.—*Platanus aceroides*. *a*, Leaf; *b*, The core of a bundle of pericarps; *c*, A single fruit or pericarp, natural size. Upper Miocene.

ORDER 12. FRANGULINÆ.—Among the more important fossil forms found in this order we may mention that in the *Celastraceæ Euonomus* (Spindle-wood) makes its first known appearance in the Miocene by forms allied to Indian types; while *Celastrus* dates from the Cretaceous of Greenland, and is known by a host of Tertiary species. The two extinct genera *Celastrophyllum* and *Celastrinites* commence in the Upper Cretaceous, the one continuing to the Pliocene but the other unknown above the Eocene. Finally, remains from the Miocene of Styria have been referred to the South American genus *Maytenus*. Whether the *Hippocrateaceæ* and *Pittosporeaceæ* occur fossil is uncertain, although Tertiary plants from Styria have been referred to *Hippocratea* and others from Provence to *Pittosporum*.

In the *Aquifoliaceæ* the genus *Ilex*, typically represented by the Holly, is abundantly represented throughout the Tertiaries, and is also recorded from the Cretaceous of both hemispheres, commencing in the Dakota stage. The extensive family of the *Rhamnaceæ* has afforded ample proof of its existence in earlier periods; thus the Old World genus *Paliurus*, and the tropical *Zizyphus* (Jujube) both date from the Cretaceous and persist in Europe till the Pliocene. In the Laramie Cretaceous and the European Tertiary we have the existing American genus *Berchemia;* while other plants from the Laramie have been made the types of an extinct genus *Rhamnites*. Finally, the genus *Rhamnus* (Buckthorn), mainly characteristic of the northern temperate zone, can be traced back to the Upper Cretaceous of the Old and New Worlds. The last family of this order is the *Vitaceæ*, in which we find *Cissus*, of the tropics, recorded from the Miocene of Croatia and elsewhere; allied Cretaceous forms described as *Cissites* and *Chondrophyllum;* while *Vitis* (Vine) itself is known to date as far back as the Laramie Cretaceous.

ORDER 13. TRICOCCÆ.—Of this order, which includes the *Euphorbiaceæ* (Spurges), *Buxaceæ* (Box), and *Empetraceæ*, the palæontological history is almost a blank; the first family being unknown in a fossil state, the second dating from the Pliocene, and the third from the Pleistocene.

ORDER 14. UMBELLIFLORÆ.—The occurrence of the typical family *Umbelliferæ*, of which Parsley is a well-known representative, in a fossil state is doubtful, but the other two families are commonly represented. Thus in the *Araliaceæ Panax* occurs in the Miocene, and has also been recorded from the Upper Cretaceous; while *Aralia* also dates from the same epoch and was abundant in the Eocene; and *Hedera* (Ivy) is first known from the early period of the Dakota stage. Finally, in the *Cornaceæ* the typical genus *Cornus* (Cornel) together with *Nyssa* make their appearance in the Upper Cretaceous.

ORDERS 15, SAXIFRAGINÆ; 16, OPUNTINÆ; 17, PASSIFLORINÆ.—Of these three orders the second is totally unknown in a fossil state, while the only trace of the third (Passion-flowers) is afforded by some exceedingly doubtful leaves from the Oligocene. In the first, however, the family *Hamamelidaceæ* is represented in the European Miocene by species of the existing Asiatic genus *Parrotia*, and by the extinct *Hamamelites* of the Lower Eocene of Sézanne, while *Liquidambar* (Sweet-gum) dates from the Cretaceous of Europe and the United States, the Cretaceous species having the leaves with entire margins.

ORDER 18. MYRTIFLORÆ.—In the *Onograceæ* the well-known genus *Trapa* (Water-chestnut), characterised by its peculiar spiked fruits and now confined to the Old World, makes its first known appearance in the Laramie Cretaceous of the United States, while in Europe it dates from the Upper Eocene (Lower Oligocene). Curiously enough *T. borealis* of the Tertiary of Alaska and the Laramie stage is allied to the existing Oriental *T. bispinosa*, and not to the four-spined European species; the writer has seen specimens from the Pliocene Siwaliks of Perim Island which probably belong to *T. bispinosa*. The family *Halorhagidaceæ* is not known before the Pleistocene; while there is only very doubtful evidence as to the occurrence of the *Combretaceæ*, *Lythrariaceæ*, and *Melastomaceæ* in a fossil state, although plants from the Eocene of Provence have been referred to *Terminalia* (*Combretaceæ*), and the name *Melastomites* has been applied to others from the Westphalian Cretaceous. In the *Myrtaceæ*, however, we have a large number of fossil forms; thus *Myrtus* (Myrtle) dates from the Upper Eocene of Provence, while an apparently allied Cretaceous type has received the name of *Myrtophyllum*. The genus *Metrosideros*, which includes several climbing species, and is now characteristic of the Moluccas and the Australasian region, appears to be represented in Europe from the Cretaceous to the Miocene; while *Eucalyptus* (Gum-tree), of Australia, occurs in the Laramie Cretaceous and the European Tertiaries. Finally, *Callistemophyllum* and *Leptospermites* are extinct European Tertiary types.

ORDER 19. THYMELINÆ.—In the two families *Thymelæaceæ* and *Eleagnaceæ* the Australian genus *Pimelea* has been recorded from the Lower Tertiary of Europe and the United States, while *Daphne* is common in the European Tertiaries. A number of fossil forms have been referred to the large family *Proteaceæ*, but since at least in some cases the determinations are doubtful it will suffice to state that plants dating from the Eocene have been referred to the existing genera *Dryandra*, *Banksia*, *Knightia*, *Lomatia*, *Grevillea*, and *Persoonia*; while as extinct types we have the Cretaceous *Dryandroides*, and the Eocene *Banksites*, *Knightites*, *Embothrites*, *Lomatites*, &c.

ORDER 20. ROSIFLORÆ.—This important order is not well represented in a fossil state, although in some genera a considerable number of species have been described. In the *Rosaceæ* the genus *Rosa* (Rose) appears to be represented by several Miocene species; while among the *Amygdalaceæ* *Prunus* (Plum) and *Amygdalus* (Almond) certainly date from the Miocene, and are perhaps of earlier origin. In the *Pomaceæ* *Pirus* (Pear) would likewise appear to occur in the Miocene, but the North American Cretaceous plant referred to this genus is probably different; while of other types *Ameliancher* (Medlar) has been recorded from the Tertiary of

Europe and the United States and also from the Laramie. *Coton-easter* dates from the Eocene of Provence, and *Cratægus* (Thorn) from the Laramie.

ORDER 21. LEGUMINOSÆ.—The large and well-known order of Leguminous plants, in which the fruit is usually in the form of a pod or legume, in which the seeds are placed, is divided into three families, of which the palæontological history is still imperfect. In the *Papilionaceæ*, characterised by their imbricate papilionaceous petals, leaves from the Miocene of Croatia have been referred to the Australian genus *Gastrolobium*, but the determination is very doubtful; and the same remark applies to those described as *Oxylobium*. *Genista* (Broom) has been recorded from the Miocene of Germany; *Cytisus* from several European Miocene deposits; and *Trigonella*, *Indigofera* (Indigo), and *Tephrosia* from the Upper Miocene of Œningen. *Robinia* apparently dates from the Lower Miocene of Germany; while *Colutea* occurs at Œningen, and is also recorded from the Cretaceous of America and Greenland; and *Erythina* is represented in the Croatian Miocene. Passing by some less important forms we may notice that *Dalbergia*, now mainly confined to India, is common in the European Tertiaries, and is also recorded from the Cretaceous; while the American *Drepanocarpus* occurs in the Eocene of Monte Bolca, the Asiatic *Pterocarpus* in the Miocene, and the American *Piscidia* in the Miocene of Croatia. *Micropodium*, *Phascolites*, and *Ervites* are extinct types from the Upper Eocene of Provence; *Palæolobium*, of the European Miocene, being also extinct. Finally, *Cercis* (Judas-tree), now represented by only a few species in the northern hemisphere, of which one occurs in southern Europe, dates from the Laramie Cretaceous, and is abundant in the Tertiaries. In the *Cæsalpiniaceæ* the genus *Gleditschia*, now confined to North America and China, occurs in the European Miocene, while *Cæsalpinia* dates from the Eocene. The Upper Eocene of Provence has yielded an extinct type termed *Cæsalpinites*. The widely spread tropical and subtropical genus *Cassia* makes its first appearance in the Cretaceous of both hemispheres; *Bauhinia* occurs in the Miocene of Croatia and Œningen; and *Ceratonia* and *Copaifera* date from the Eocene. *Hymenæa*, of tropical America, is found in the Cretaceous of France and New Jersey; and the extinct *Podogonium* ranges from the Laramie Cretaceous to the Œningen Miocene. In the third family, or *Mimosaceæ*, *Prosopis* and *Inga* are described from the Eocene of Eubæa; while *Mimosa* and *Acacia* date from the Upper Eocene of Provence. In conclusion we have to mention the extinct genus *Leguminosites* (fig. 1415, *c*), ranging from the Cretaceous to the Miocene, of which the serial position is at present undetermined.

ORDER 22. HETEROPHYLLEÆ.—With this order we come to the end of the Choripetalæ. In the *Aristolochiaceæ*, the type genus

Aristolochia, which includes climbing plants, usually having coloured sepals, dates from the Dakota Cretaceous, and also occurs in the European Miocene. The occurrence of fossil representatives of the *Santalaceæ* is open to some doubt; but remains attributed to the genera *Leptomeria*, *Osyris*, and *Santalum* have been described from the European Eocene and Miocene. The alleged occurrence of fossil representatives of the *Rafflesiaceæ* and *Balanophoraceæ* is too doubtful to need mention.

DIVISION B. SYMPETALÆ.—With this second primary division of the Dicotyledons we reach the last and most specialised group of plants, characterised by the union of the lower part of the petals into a complete tube. These plants are dependent entirely, or to a great extent, upon the aid of insects for their fertilisation, and a large proportion of them are in all probability of comparatively modern origin. The group is frequently termed Gamopetalæ, and is divided into nine orders.

ORDER 1. BICORNES.—The family *Ericaceæ* is important from the effect which its massed foliage produces upon the landscape of many regions of the globe. Its type genus *Erica* (Heath), which is exclusively Old World, and very characteristic of the Cape, appears to be unknown before the Upper Miocene of Œningen; while *Andromeda* and *Leucothea* date from the Eocene. *Gaultheria* has likewise been traced back to the Eocene, in which period occur the extinct types described as *Andromedites* and *Arbutites*, and also a species referred to the existing genus *Arbutus*. The Rhododendrons, which some writers make the type of a distinct family, are represented by species of the widely-spread genus *Rhododendron* in the Eocene and Miocene, and by *Azalea* in the Miocene of Croatia and elsewhere. In the *Vacciniaceæ*, the type genus *Vaccinium* (Cranberry) is recorded from the Upper Eocene of Provence and higher deposits.

ORDER 2. PRIMULINÆ.—In this order the subtropical and tropical genus *Myrsine*, the type of the family *Myrsiniaceæ*, is said to date from the Upper Cretaceous, and is well represented in the Eocene of Provence and the higher Tertiaries. *Myrsinites* is an extinct Tertiary type; and we also find in the Tertiary representatives of *Ardisia*, and some other forms of doubtful affinity.

ORDER 3. DIOSPYRINÆ.—Coriaceous leaves, found in the Upper Cretaceous of Greenland and the United States, and also in the Lower and Middle Tertiaries, have been described under the name of *Sapotites* as being allied to the American and Australian genus *Sapota*, the type of the family *Sapotaceæ*. The existing American genus *Bumelia* occurs in the Green River Eocene of that country, and also in the Eocene of Provence and other Old World Tertiaries. *Achras*, which is likewise now exclusively American, has been described from the Croatian Miocene. In the *Ebenaceæ* the genus

Diospyros (Ebony), now mainly tropical, is represented by a few species in the Dakota and Greenland Cretaceous, is very abundant in the Upper Eocene of Provence, but has almost disappeared from Europe in the Miocene. Finally, in the *Styracaceæ*, the existing Asiatic and American genus *Symplocos* dates from the Lower Eocene of Europe.

ORDER 4. CONTORTÆ.—In this order the *Gentianaceæ* (Gentians) are unknown before the Pleistocene. In the *Oleaceæ*, which includes most of the European trees belonging to the present division, *Olea* (Olive) makes its appearance in the Eocene of Provence; while the Australian genus *Notelæa* is recorded from the Eocene and Miocene of the Continent; and *Fraxinus* (Ash) occurs as far back as the Laramie Cretaceous. In the *Apocyanaceæ* we may mention *Nerium*, from the European Cretaceous and Tertiary, and *Tabernæmontana*, from the Eocene and Miocene; together with the extinct *Echitonium*, of the Eocene, and *Apocynophyllum*, of the Cretaceous and Tertiary.

ORDER 5. TUBIFLORÆ.—In the Convolvulaceæ the tropical genus *Parana* occurs in the Upper Miocene of Œningen, and the somewhat older Tertiary of Croatia; while plants from the upper lignites of Winterhafen have been referred to *Convolvulus*. It is very doubtful if the *Asperifoliaceæ* are represented in a fossil condition, while the *Solanaceæ* (Night-shade, Potato, Tomato, Tobacco, &c.), are unknown.[1]

ORDER 6. LABIATIFLORÆ.—The only family of this order of which we have any certain palæontological record is that of the *Bignoniaceæ*, in which we have representatives of the existing American genus *Catalpa* in the Laramie Cretaceous, and perhaps in the European Tertiaries. The occurrence of *Bignonia* in the latter is very doubtful.

ORDER 7. CAMPANULINÆ.—This group, containing the Campanulas, Gourds, &c., seems to be unknown before the present epoch.

ORDER 8. RUBIÏNÆ.—In this order the *Rubiaceæ* are represented in the Miocene of Bonn by the extinct *Rubiacites;* and we have evidence of the existence of the handsome Asiatic and African genus *Gardenia* in the Miocene of Œningen and the Lower Eocene of the Soissonais. In the *Caprifoliaceæ*, the widely-spread genus *Viburnum* is represented by a number of species in the Laramie Cretaceous, and less commonly in the Tertiaries. The Miocene of Œningen has yielded remains of *Lonicera*.

SUBORDER 8. AGGREGATÆ.—With the specialised *Compositæ* we come to the end of our brief survey of the palæontological history of the Vegetable Kingdom. These plants are characterised by the

[1] The Eocene *Solanites* does not belong to this family.

collection of the small separate flowers in a common receptacle, the peripheral florets being modified into strap-like rays surrounding the fertile flowers of the disk. All the fossil forms have been referred to extinct genera, and include *Parthenites* and *Cypselites*, of the Upper Eocene of Provence; *Bidentites*, from the Upper Miocene of Œningen; *Hyoserites*, from the Tertiary of Priesen; *Hieracites*, from Provence; and *Silphidium*, from the Tertiary of Chiavon, which is supposed to be allied to the existing *Silphium*.

In this place it may be well to mention certain flowers from the Amboy Clays of New Jersey—the equivalents of the Dakota Cretaceous—which have been described under the name of *Palæanthus*, and are stated to present resemblances to those of the *Compositæ*. Dr Newberry observes, however, that "though these flowers so much resemble those of the *Compositæ*, we are not yet warranted in asserting that such is certainly their character."

LITERATURE.

The subjoined list comprises only a very limited selection from the great series of works and memoirs dealing with the subject of Palæobotany. The student desirous of fuller information as to the sources of knowledge as to fossil plants should consult the "Literaturverzeichniss" given by Count Solms-Laubach in his "Einleitung in die Paläophytologie" and the complete bibliography of works treating of Palæozoic plants given by Mr Kidston in his "Catalogue of the Palæozoic Plants in the British Museum."

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APPENDIX

APPENDIX.

I. INVERTEBRATE ANIMALS.

FORAMINIFERA.

MR E. WETHERED has shown ('Geol. Mag.,' May 1889) that forms of *Girvanella* (see p. 127) occur abundantly in some of the Jurassic limestones of Britain. Mr Wethered has also made the interesting observation that the spheres of some of the so-called "pisolites" of the Jurassic series are in reality formed by the growth of layers of *Girvanella* round a central nucleus, and are, therefore, not of the nature of ordinary oolitic grains.

RECEPTACULITIDÆ (p. 170).

The remarkable fossils which are grouped together under the name of *Receptaculitidæ* have recently formed the subject of an important investigation by Herr Rauff ('Zeitschr. d. Deutschen Geol. Gesellschaft,' Bd. XL.) The following are the principal general conclusions at which this observer has arrived:—

1. The *Receptaculitidæ* are spherical or pyriform bodies, with a central closed cavity, the supposed basin-shaped examples being only fragments of the base.

2. Each of the individual spicular elements forming the wall of the body is composed of six parts—viz., an external plate of an essentially rhombic form, four diagonally intersecting tangential arms which lie immediately below the outer plate, and a radial arm or pillar which springs from the centre of the outer plate on its inner side, and is directed perpendicularly inwards.

3. An upper and lower pole may be distinguished on the exterior

surface, the arrangement of the plates at these points being peculiar. The basal pole (the starting-point of growth) is constituted by a circle of eight (or four) plates. The apical pole is closed by a variable, but always large, number of plates.

4. Each of the five arms of the skeletal elements or spicules is traversed by an axial canal, the canals of the four tangential arms having a conspicuously fusiform shape.

5. The radial arms or pillars terminate on the inner or "gastral" side in a conical dilatation, which is laterally extended till adjoining pillars touch. This internal thickening of the radial pillars is not furnished with a special plate, corresponding with the external plate, and is not penetrated by transverse canals.

6. The inner or "gastral" wall of the fossil is imperforate, the pores described by Billings being the result of fossilisation.

7. The genus *Ischadites* agrees essentially with *Receptaculites* in structure, but its skeletal elements are more slender. An apical aperture is in some cases clearly wanting in *Ischadites*, and probably did not exist at all.

8. The genus *Acanthochonia* is identical with *Ischadites*.

9. The geological range of *Ischadites* extends to the Upper Devonian.

10. The genus *Polygonosphærites* (*Sphærospongia*) is similarly constructed to *Receptaculites* as regards the tangential arms of the spicules, but the radial arms or pillars are wanting.

11. The *Receptaculitidæ* are not *siliceous* organisms, but the skeleton was originally *calcareous*, and the siliceous examples are the result of silicification. The group, therefore, cannot be referred to the Hexactinellid Sponges, and its systematic position is still entirely uncertain.

MASTOPORA AND CYCLOCRINUS (p. 186).

In the memoir just referred to, Herr Rauff expresses the opinion that the genera *Mastopora* (*Nidulites*) and *Cyclocrinus* have no relationships with the *Receptaculitidæ*, but that they appear to be related to the *Polyzoa*.

CALCISPONGIÆ (p. 178).

Some interesting discoveries as to the occurrence of Mesozoic Sponges have recently been made by Dr George J. Hinde, who has been good enough to furnish the following note of his investigations on this point: "In the Middle Lias of Northamptonshire (zone of *Ammonites spinatus*) some very minute Calcisponges have been lately discovered, with the same delicate structural characters as in the existing family of the *Leucones*, Haeckel, and they have even been placed in the recent genus *Leucandra*, Haeckel. The largest of these fossil sponges is under 4 mm., or about one-sixth of an inch in height, and the spicules in their walls are as perfect as in recent specimens. A remarkable assemblage of small Calcisponges has also been discovered by Mr Walford in the Inferior Oolite (zone of *Ammonites Parkinsoni*) of Dorset. In their diminutive proportions they resemble living Calcisponges, but they all possess a structure of solid fibres, characteristic of *Pharetrones*. They mostly belong to the genera *Eudea*, *Peronella*, *Blastinia*, and to a new genus not yet described. Calcisponges of larger dimensions, belonging to *Peronella* and *Lymnorea*, are also abundant in the Inferior Oolite of Cheltenham. Certain zones of the Great Oolite in the neighbourhood of Bath are very rich in Calcisponges, principally of the genus *Peronella*. Higher up in the Oolitic series there is a well-marked zone of Calcisponges in the Lower Coral Rag of Yorkshire. They have mostly been hitherto placed in *Stellispongia*; species of *Peronella* and *Blastinia* are also present."

STROMATOPOROIDEA (p. 229).

Since the earlier portion of the present work was written, the author has had the opportunity of studying the fasciculus of Dr Waagen's Monograph on the "Salt Range Fossils," which deals with the *Hydrozoa* ('Palæontologia Indica,' Ser. XII., No. 7, 1877). The most important point brought out in this memoir is, that the "Productus Limestone" of the Salt Range of India, the age of which is Permo-Carboniferous, contains various *Hydrozoa* which are more or less closely related to *Stromatopora* proper. For these the new genera *Disjectopora*, *Circopora*, *Carterina*, and *Irregulatopora* are proposed; but it would be impossible to make the structure of these intelligible without illustrations. It may, however, be considered as proved that the geological range of the Stromatoporoids, as a group, has by these researches been extended into the beginning of the Permian period; the latest undoubted types of the group previously known being Upper Devonian.

Dr Waagen, further, deals at some length with the general structure and zoological affinities of the Stromatoporoids. He divides them into two families, and refers them to the *Hydrocorallinæ*. It is unnecessary, however, to discuss Dr Waagen's views on these subjects here; since the conclusions which he has reached would probably have been more or less modified had he been acquainted with the previously published "Monograph on the British Stromatoporoids" (Palæontographical Society, 1885) by the present writer, in the general introduction to which the same questions have been dealt with in considerable detail.

CLASSIFICATION OF THE CRINOIDEA (p. 445).

Dr P. Herbert Carpenter has kindly supplied the author with the following note as to the classification of the Crinoids proposed by Neumayr in his recently published important work "Die Stämme des Thierreichs": "The new classification of the *Crinoidea* proposed by Neumayr is primarily based upon the condition of the mouth and ambulacra. These are either subtegminal (*Hypascocrinæ*) or free and exposed upon the ventral surface (*Epascocrinæ*). The first-named group includes all the Palæocrinoids, except *Cyathocrinus* and its allies (Families 12–20), which have been already distinguished as *Fistulata* by Wachsmuth and Springer. It has also been shown by these authors that some of the *Ichthyocrinidæ*, at any rate, had an exposed mouth and open ambulacra (see p. 431); so that this family can find no place in the *Hypascocrinæ*. Except, too, for having a subtegminal mouth, the *Haplocrinidæ* and their allies (*Larviformia*) seem to be more closely allied to the *Fistulata* than to the other Palæocrinoids (*Camerata*)."

The general relations of Neumayr's classification to that proposed by Wachsmuth and Springer may be seen in the following table:—

	NEUMAYR.		WACHSMUTH AND SPRINGER.	
HYPASCOCRINÆ.	Sphæroidocrinacea		Camerata	Coadunata.
			Reticulata (joined by a line to Crotalocrinidæ)	
	Haplocrinacea		Larviformia	Inadunata.
			Fistulata (joined by a line to Cyathocrinacea)	
	Ichthyocrinacea	Crotalocrinidæ		
		Ichthyocrinidæ	(joined by a line to Impinnata)	
		Uintacrinidæ	(joined by a line to Pinnata)	
EPASCOCRINÆ.	Cyathocrinacea		Impinnata	Articulata.
	Pentacrinacea		Pinnata	

CYSTOIDEA (p. 447).

An important posthumous work by M. Joachim Barrande on the Cystideans of Bohemia has recently been published, and Dr P. Herbert Carpenter has been good enough to furnish the author with the following note as to its contents:—

"This elaborate work contains descriptions of a large number of new Cystideans from the Lower Palæozoic rocks of Bohemia. Some valuable morphological observations are also recorded therein; but most of them refer to questions of too complex a nature for discussion here. One point, however, must be noticed. In the new genus *Aristocystites* and in some half-dozen others Barrande describes the calcareous plates of the test as covered by a smooth 'external epidermis' which completely closes the openings of the pore-canals that penetrate the substance of the plates. This epidermis is very thin, not more than $\frac{1}{100}$ part of an inch in *Proteocystites*, and is therefore but rarely preserved to any great extent. The pores are sometimes isolated (haplopores), or a pair may be linked by a horse-shoe-shaped groove, or open together in a small oval depression, the 'oscule,' the whole structure being commonly known as a 'diplopore.' It was the resemblance of these diplopores to the groups of twin ambulacral pores in the Ordovician Sea-Urchin *Bothriocidaris*, which led Lovén to point out that the old theory of the connection of the diplopores of the Cystideans with the ambulacral system might after all be correct. This view, however, will have to be abandoned altogether if the pores really are closed by the external epidermis in the manner described by Barrande. But there is some doubt as to whether the appearances described by him may not be capable of a different interpretation, more especially as he suggests in one place that the pores may have been connected with tube-feet like those of the Urchins, while in another he notices their similarity to the respiratory pores of the Asterids which give passage to the gills or papulæ. But neither of these explanations could be possible if the pores really are closed as he describes.

"Neumayr, believing Müller's classification of the Cystidea according to the characters of their pores to be no longer a practicable one, has recently proposed the following scheme, which may be adopted until a fuller morphological knowledge of the group has provided us with the materials for a better one.

"I. Order Sphæronitidæ.—Test composed of numerous irregularly disposed plates, which may be aporous or bear haplopores or diplopores, but never rhombs. Five ambulacra, sometimes terminating in feebly developed arms. Generally sessile, but sometimes free or stalked.

"*Family* 1. *Sphæronitinæ*.—Ambulacra superficial and branching. *Sphæronites*, *Glyptosphærites*, *Eucystis*, *Proteocystites*, *Protocrinus*.

"*Family* 2. *Aristocystinæ*. Ambulacra subtegminal and branching. *Aristocystites*, *Pyrocystites*, *Craterina*.

"*Family* 3. *Mesitinæ*. Ambulacra superficial and simple. *Mesites*, *Agelacrinus*, *Edrioaster*, *Cytaster*, *Hemicystites*.

"II. Order Echinosphæritidæ.—Test composed of numerous rhombiferous plates; often with only three ambulacra, and slightly developed arms. Sessile or stalked. *Echinosphærites*, *Dendrocystites*, *Caryocystites*, *Arachnocystites*.

"III. ORDER PLEUROCYSTIDÆ.—Test shortly stalked and asymmetrical, the plates of the two sides being differently arranged except in the oldest genera (*Trochocystites*). Arms few and small. *Pleurocystites*, *Ateleocystites*, *Balanocystites*, *Mitrocystites*.

"The above scheme takes no account of such types as *Caryocrinus*, *Porocrinus*, *Echinoencrinus*, *Lepadocrinus*, *Callocystites*, and several other forms in which the plates of the test are few in number, with a more or less regular arrangement as in the Crinoids; while in *Cystoblastus* and *Asteroblastus* there is a calyx very similar to that of the Blastoidea. Most of these genera have hydrospires, either generally distributed on the calyx plates (*Caryocrinus*), or limited to a few of them as in *Echinoencrinus*, while *Asteroblastus* has diplopores.

"As at present constituted the class of the Cystidea is an extremely heterogeneous one, and much further investigation will be necessary before anything like a natural classification of the group becomes at all possible."

BACTRITES (p. 846).

According to the observations of Branco ('Zeitschr. d. Deutschen Geol. Gesellschaft,' Bd. XXXVII., 1885), the initial chamber of the shell of *Bactrites* is an ovoid and dilated sac, similar to that of the shell of the Ammonoids and of *Spirula*. The genus *Bactrites* must therefore be removed to the *Ammonoidea*. According to the views of Branco, the genus should be ranked with the *Goniatitidæ*, the particular group of these to which it is referable occupying an intermediate position, as regards the form of the initial chamber, between the *Ammonitidæ* and the *Belemnitidæ*.

II. VERTEBRATA.

PISCES.

CHIMEROIDEI.—As is mentioned in the Addenda, Mr Smith Woodward has recently made the genus *Myriacanthus* (p. 951) the type of the family *Myriacanthidæ*, which is defined as follows: Body elongated; anterior dorsal fin placed above the pectoral, and furnished with a long, straight spine. Teeth forming two or three pairs of thin dental plates in the upper jaw, the hinder pair alternated and not closely approximated in the middle line; lower teeth consisting of a pair of large dental plates meeting at the symphysis, and a median incisor-like tooth in front. A few dermal plates on the head; and a long prehensile spine upon the muzzle of the male.

Incertæ sedis.—Remains of a fish from the Oxford Clay of Peterborough have been described as *Leedsichthys*,[1] which apparently indicates the largest Jurassic representative of the class, although its serial position cannot yet be determined. A bone which is regarded as the frontal has a length of 24 inches, while the squamous hyomandibular is at least 15 inches long. The most remarkable features of this fish are, however, shown in the pectoral fin-rays, which sometimes attain a length of 5 feet, and frequently branch in a forked manner, but are not jointed. Each ray consists of fibrous bone, and appears to be composed of a number of long and tapering splints which are incompletely fused together, and the two halves of the ray remain separate.

Reptilia.

Anomodontia.—The author's recent study of the Anomodont remains in the British Museum has enabled him to make some amendments on the characters of the families and genera given in the text.

In *Tapinocephalus* (pp. 1057-58) the dentition, although it may have been of a carnivorous type, was not differentiated into incisives, tusks, and cheek-teeth; and it is highly probable that there were no secondary nares. It does not appear by any means certain that the one tooth on which the genus *Glaridodon* (p. 1061) is founded, is really distinct from *Titanosuchus* (p. 1058).

In the *Galesauridæ* (pp. 1058-59) the single narial aperture of the type specimen of *Ælurosaurus* is due to imperfection; and it is probable that the same is the case with *Cynodraco*, *Cynochampsa*, and *Cynosuchus*.[2] The latter has 7 or 8 cheek-teeth, with a posterior basal cusp, but the incisive and cheek-teeth appear to have no serrations on the posterior edge. *Cynochampsa* was probably allied, having $\frac{4}{3}$ incisive teeth as in *Cynosuchus*. In *Cynodraco* and the type of *Ælurosaurus* there are $\frac{5}{4}$ incisive teeth; and the crowns of the incisive and cheek-teeth have serrated posterior edges; and it has yet to be proved that *Ælurosaurus* is generically distinct from *Cynodraco*. In *Tigrisuchus* there are three pairs of upper incisive teeth.

Gorgonops (p. 1059) differs from the *Galesauridæ* in having the temporal fossæ roofed over, and apparently in the absence of second-

[1] The practice of making such barbarous compounds as *Leedsichthys*, *Oweniasuchus* (p. 1191), and *Wardichthys* (p. 979), is much to be deprecated. If a change be permissible, the terms *Leedsia* and *Wardia* may be suggested in place of the first and third of these uncouth names.

[2] By an error (see Corrigenda) these three genera are stated to have double nares, while in *Tigrisuchus* the nares are said to be single.

ary posterior nares. Roofed temporal fossæ also occur in the American genus *Chilonyx* (p. 1060); so that both of these forms approximate in this respect to the Pariasauria, although distinguished from the typical representatives of that group by the absence of sculpture on the cranial bones. *Gorgonops* may be regarded as the type of the family *Gorgonopidæ*, with an uncertain serial position.

The genus *Embolophorus* (p. 1060) is the only one in which the articulation of the capitula of the ribs to the intercentra has yet been observed.

It appears that there is no justification for Eichwald's reference of the tooth represented in fig. 983 (p. 1062) to *Deuterosaurus* rather than to *Brithopus;* the former genus having been founded upon part of the vertebral column of a smaller reptile than the one to which the humerus of *Brithopus* belonged.

The vertebræ of the *Diadectidæ* (p. 1061) are distinguished by the presence of zygosphenal (hyposphenal) articulations; while the skull has no secondary posterior nares. *Empedias* differs from *Diadectes* by the absence of a tusk; while *Helodectes* is distinguished from both by the double row of cheek-teeth.

SAUROPTERYGIA.—It is stated on page 1077 that the genus *Cimoliosaurus* has no trace of an interclavicle; it has, however, been subsequently suggested that certain splint-like bones found with some skeletons of the Oxfordian representatives of this genus are really the last remnants of the interclavicle and clavicles; the interclavicle probably fitting into the notch shown between the ventral plates of the scapulæ in fig. 988 (p. 1069).

CHELONIA.—In a recent paper Dr Baur states that in the skull of *Protostega* (p. 1089) the parietals were connected by vertical plates with the pterygoids, and he accordingly regards the *Protostegidæ* as less specialised than the *Dermochelyidæ*. If this reference be correct there will be evidence of a nearer affinity between the Athecata and Testudinata than has hitherto been supposed.

The same writer also doubts the Chelonian nature of the problematical *Psephoderma* (p. 1089), and suggests that it may be founded upon the dermal armour of *Nothosaurus*. This argument is supported by the absence of Chelonian bones in the Lettenkohle (Lower Keuper), where *Psephoderma* is not uncommon; but the absence of a dermal armour in the *Lariosauridæ*, so far as it goes, is against this view.

In the *Testudinidæ* the genus *Palæochelys* (p. 1108), as is well shown by a specimen from the Pliocene of Italy recently described as *Emys Portisi*, has some of the neural bones tetragonal and others octagonal, and is thereby more nearly allied to *Nicoria* and the land tortoises than to *Ocadia*. The so-called *Emys crassa*, of the Upper Eocene of Hampshire, is, therefore, referable to *Ocadia*.

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[1] = *Leptodactylidæ*. See Corrigenda.

[2] = *Xenopodidæ*. See Corrigenda.

[1] *Limnotherium* in text. See Corrigenda.

[1] = *Platysomatidæ*. See Corrigenda.

[1] *Errore Saurinichthys*. See Corrigenda.

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