exposure of the collodion the faculæ first disappear, then the penumbræ round the spots, and lastly the spots themselves. In the photograph the difference in the intensity of the sun's limb and central portions is very marked, but an over-exposure prevents also this from being seen in the photograph. The solar spots and faculæ delineated by the Kew Photoheliograph bear examination with a lens of moderate power, and show details not visible to the unassisted eye. The faculæ and spots are sufficiently marked to make the sun appear globular when two views taken at a sufficient interval are grouped together in the stereoscope, as will be seen by the slides now before the Meeting. There is not the same difficulty in obtaining stereoscopic pairs of views of the sun as there is in the case of the moon, because any two views taken at an interval of about a day give a perfectly spherical figure in the stereoscope. When the principal spots are near either limb, two views taken at an interval of two days will combine, and even slight changes in the form of the spots do not prevent the perfect coalition of the two pictures.

Having already most fully described the methods pursued and the precautions to be taken to ensure good results in the case of photoselenography, it will be unnecessary for me here to enter into any details of the chemical part of the processes of photoheliography, for the methods are nearly the same in both cases. So far from seeking a surface less sensitive than ordinary collodion, it has been found advisable to use both the bath and collodion in a very sensitive condition, though it is not of course necessary to strain this sensitiveness to the utmost extent for solar photography, as in the case of lunar photography. The bath must, however, be always brought back to its best working state by means of oxide of silver, and subsequent addition of dilute nitric acid in case it has become acid by use. The collodion moreover is used in that condition which photographers would call very sensitive.

On the Orders of Fossil and Recent Reptilia, and their Distribution in Time. *By* Professor Owen.

[A communication ordered to be printed entire among the Reports.]

With the exception of geology, no collateral science has profited so largely from the study of organic remains as zoology. The catalogues of animal species have received immense accessions from the determination of the nature and affinities of those which have become extinct, and much deeper and clearer insight has been gained into the natural arrangement and subdivision of the classes of animals since Palæontology has expanded our survey of them. Of this the class *Reptilia*, or cold-blooded air-breathing vertebrates, affords a striking example.

In the latest edition of the 'Règne Animal' of Cuvier, 1829, as in the 'Elémens de Zoologie' of Milne-Edwards (1834–37), and in the more recent monograph on American *Testudinata* by Prof. Agassiz, 4to, 1857, the quadruple division of the class, proposed by Brongniart in 1802, is adhered to, viz. *Chelonia* (Tortoises, Turtles); *Sauria* (Crocodiles, Lizards); *Ophidia* (Serpents); *Batrachia* (Frogs, Newts); only the last group is made a distinct class by the distinguished Professor of the United States*. In my former Reports on Fossil Reptiles to the British Association, in 1839 and 1841, it was proposed to divide the class into eight orders, viz.—*Ena-*

* "After this separation of the Batrachians from the true Reptiles, we have only three orders left in the class Reptiles proper—the Ophidians, the Saurians, and the Chelonians." —*l. c.* p. 239.

liosauria, Crocodilia, Dinosauria, Lacertilia, Pterosauria, Chelonia, Ophidia and *Batrachia*, which orders were then severally characterized.

Subsequent researches have brought to light additional forms and structural modifications of cold-blooded air-breathing animals now extinct, which have suggested corresponding modifications of their distribution into ordinal groups. Another result of such deeper insight into the forms that have passed away has been the clearer recognition of the artificiality of the boundary between the classes *Pisces* and *Reptilia* of modern zoological systems.

The conformity of pattern in the arrangement of the bones of the outwardly well-ossified skull in certain fishes with well-developed lung-like air-bladders, e. g. *Polypterus, Lepidosteus, Sturio*, and in the extinct reptiles *Archegosaurus* and *Labyrinthodon*;—the persistence of the notochord (*chorda dorsalis*) in *Archegosaurus*, as in *Sturio*; the persistence of the notochord and branchial arches in *Archegosaurus* and *Lepidosiren*; the absence of occipital condyle or condyles in *Archegosaurus* as in *Lepidosiren*; the presence of teeth with the labyrinthic interblending of dental tissues in *Dendrodus, Lepidosteus*, and *Archegosaurus*, as in *Labyrinthodon*; the large median and lateral throat-plates in *Archegosaurus*, as in *Megalichthys*, and in the modern fishes *Arapaima* and *Lepidosteus*;—all these characters, as were explained and reasoned upon in my lectures at the Government School of Mines (March, 1858), pointed to one great natural group, remarkable for the extensive gradations of development linking and blending together piscind and reptilian characters within the limits of such group. The salamandroie (or so called 'sauroid') Ganoids, e. g. *Lepidosteus* and *Polypterus*, are the most ichthyoid, the Labyrinthodonts are the most sauroid, of this annectent group: the *Lepidosiren* and *Archegosaurus* are intermediate gradations, one having more of the piscine, the other more of the reptilian characters. *Archegosaurus* conducts the march of development from the fish proper to the labyrinthodont type; *Lepidosiren* conducts it to the perennibranchiate or modern batrachian type. Both forms expose the artificiality of the ordinary class-distinction between *Pisces* and *Reptilia*, and illustrate the naturality of the wider class of cold-blooded vertebrates, which I have called *Hæmatocrya**.

Reptiles are defined as 'cold-blooded air-breathing vertebrates,' but the *Siren* and *Proteus* chiefly breathe by gills, as did, most probably, the *Archegosaurus*. The modern naked *Batrachia* annually mature, at once, a large number of small ova; the embryo is developed with but a small allantoid appendage, and is hatched and excluded with external gills. These are retained throughout life by a few species; the rest undergo a greater or less degree of metamorphosis. Other existing reptiles have comparatively few and large eggs, and the embryo is enclosed in a free amnios and is more or less enveloped by a large allantois; it undergoes no marked transformation after being hatched.

On this difference, the *Batrachia* have been, by some naturalists, separated as a distinct class from the *Reptilia*. But the number of ova simultaneously developed in the viviparous Land Salamanders is much less than in the Siren, and not more than in the Turtle; and, save in respect of the external gills which disappear before or soon after birth, the Salamander does not undergo a more marked transformation, after being hatched, than does the Turtle or Crocodile†. It depends, therefore, upon the value assigned to the different proportions of the allantois in the embryo of the salamander and lizard, whether they be pronounced to belong, or not, to distinct classes of animals.

* αἷμα, blood, κρύος, cold; the correlative group is the '*Hæmatotherma*.'

† The *Cæcilia* may probably depart still further from the type-batrachian mode of development, and approach more to the type-reptilian mode.

This embryonic or developmental character is unascertainable in the extinct *Archegosaurus* and *Labyrinthodon*. The signs of affinity of *Labyrinthodon* to *Ichthyosaurus*, and those structures which have led the ablest German palæontologists to pronounce the Labyrinthodonts to be true Saurians under the names of *Mastodonsaurus*, *Trematosaurus*, *Capitosaurus*, &c., may well support the conjecture that modifications more 'reptilian' than those in *Salamandra* did attend the development of the young Labyrinthodont.

Characters derived from the nature of the cutaneous coverings equally fail to determine the class-characters of *Batrachia* as contradistinguished from *Reptilia*. It is true that all existing *Batrachia* have a scaleless skin, or very minute scales (*Cæcilia*), but not all existing Reptiles have horny scales. The Crocodiles and certain Lizards show a development of dermal bones similar to that in certain placoid and ganoid fishes. This development characterizes the cutaneous system in the Labyrinthodont genus *Anisopus*; and in regard to the dermal ossifications of the cranium, the resemblance to the *Ganoidei* is closer in those ancient forms of *Reptilia* which exhibit in their endoskeleton unmistakeable signs of their affinity to fishes and batrachians.

In the survey which, with a view to communicate its results to the present Meeting of the British Association, I have made of all the known forms of cold-blooded air-breathing Vertebrates, recent and fossil, I have to acknowledge myself unable to define any adequate boundary for dividing them into two distinct classes of Batrachians and Reptiles; and I am as little able to point out a character dividing the air-breathing from the water-breathing *Hæmatocrya*—the Reptiles from the Fishes.

In the present Report, therefore, an arbitrary line has been drawn, in order to define its subject, between *Lepidosiren* and *Archegosaurus*, and the review of the ordinal groups of *Reptilia*, or air-breathing *Hæmatocrya*, will commence with that of which the *Archegosaurus* is the type.

Order I. Ganocephala.

The name of *Ganocephala*, for this group or order (*γάνος*, lustre; *κεφαλή*, head), has reference to the sculptured and externally polished or ganoid bony plates with which the entire head is defended. These plates include the 'post-orbital' and 'super-temporal' ones, which roof over the temporal fossæ. There are no occipital condyles. The teeth have converging inflected folds of cement at their basal half. The notochord is persistent, the vertebral arches and peripheral elements are ossified, the pleurapophyses are short and straight; there are both pectoral and pelvic limbs, which are natatory and very small; there are large median and lateral 'throat-plates': the scutes are small, narrow, subganoid. Some of the fossils show traces of branchial arches. The above combination of characters gives the value of an ordinal group in the cold-blooded Vertebrata.

The extinct animals which manifest it were first indicated by certain fossils discovered in the sphærosideritic clay-slate forming the upper member of the Bavarian coal-measures, and also in splitting spheroidal concretions from the coal-field of Saarsbrück near Treves; these fossils were originally referred to the class of Fishes (*Pygopterus Lucius*, Agassiz). But a specimen from the 'Brandschiefer' of Münster-Appel presented characters which were recognized by Dr. Gergens to be those of a Salamandroid Reptile*.

* Mainz, Oktober 1843.—"In dem Brandschiefer von *Münster-appel* in *Rhein-Baiern* habe ich in vorigen Jahre ∞ einen Salamander aufgefunden":—"Gehort dieser Schiefer der Kohlen-formation?—in desene falle wäre der Fund auch in anderen Hinsicht interessant." Leonhard und Bronn, Neu Jahrbuch für Mineralogie, &c., 1844, p. 49.

Dr. Gergens placed his supposed 'Salamander' in the hands of M. Hermann von Meyer for description, who communicated the result of his examination in a later number of the under-cited journal*.

In this notice the author states that the Salamander-affinities of the fossil in question, for which he proposes the name of *Apateon pedestris*, "are by no means demonstrated†..... Its head might be that of a fish, as well as of a lizard or of a batrachian..... There is no trace of bones or limbs." M. v. Meyer concludes by stating that, "in order to test the hypothesis of the *Apateon* being a fossil fish, he has sent to Agassiz a drawing with a description of it."

Three years later, better preserved and more instructive specimens of the problematical fossil were obtained by Professor von Dechen from the Bavarian coal-fields, and were submitted to the examination of Professor Goldfuss, of Bonn. The latter palæontologist published a 4to memoir on them, with good figures, referring them to a Saurian genus which he calls *Archegosaurus*, or 'primeval lizard,' deeming it to be a transitional type between the fish-like Batrachia and the Lizards and Crocodiles‡.

The estimable author, on the occasion of publishing the above memoir, transmitted to the Reporter excellent casts of the originals therein described and figured. These casts were presented to the Museum of the Royal College of Surgeons, London, and were described by me in the 'Catalogue of the Fossil Reptiles' in that Museum (4to, 1854). The conclusions which I then formed as to the position and affinities of the *Archegosaurus* in the Reptilian class are published in that Catalogue, and were communicated to and discussed at the Geological Society of London (see the 'Quarterly Journal of the Geological Society,' vol. iv. 1848).

One of the specimens appeared to present evidence of persistent branchial arches. The osseous structure of the skull, especially of the orbits, through the completed zygomatic arches, indicated an affinity to the Labyrinthodonts; but the vertebræ and numerous very short ribs, with the evidence of stunted swimming limbs, impressed the Reporter with the conviction of the near alliance of the *Archegosaurus* with the *Proteus* and other perennibranchiate reptiles.

This conclusion of the affinity of *Archegosaurus* to existing types of the Reptilian class is confirmed by the subsequently discovered specimens, described and figured by M. von Meyer in his 'Palæontographica' (Bd. vi. Heft 2. 1857), more especially by his discovery of the embryonal condition of the vertebral column§, *i. e.* of the persistence of the notochord, and the restriction of ossification to the arches and peripheral vertebral elements.

In this structure, the old carboniferous Reptile resembled the existing *Lepidosiren*, and thus affords further ground for regarding that remarkable existing animal as one which obliterates the line of demarcation between the Fishes and the Reptiles.

Coincident with this non-ossified state of the basis of the vertebral bodies of the trunk is the absence of the ossified occipital condyles, which condyles characterize the skull in better developed *Batrachia*. The fore part of the notochord has extended, as in *Lepidosiren*‖, into the basi-sphenoid region,

* Leonhard und Bronn, Neues Jahrbuch für Mineralogie, 1844, p. 336.

† "Ob das—*Apateon pedestris*—ein Salamander-artiges Geschöpf war, ist keineswegs ausgemacht."

‡ "'Archegosaurus,' Fossile Saurier aus dem Steinkohlengebirge die den Uebergang der Ichthyoden zu den Lacerten und Krokodilen bilden," 'Beitrage zur vorweltlichen Fauna des Steinkohlengebirges' (4to, 1847), p. 3.

§ 'Reptilien aus der Steinkohlen-Formation in Deutschland,' Sechster Band, p. 61.

‖ Linn. Trans., vol. xviii. p. 333, pl. 24, fig. 2.

and its capsule has connected it, by ligament, to the broad flat ossification of expansions of the same capsule, forming the basi-occipital and basi-sphenoid plate.

The vertebræ of the trunk in the fully developed full-sized animal present the following stage of ossification. The neurapophyses coalesce at the top to form the arch, from the summit of which is developed a compressed, subquadrate, moderately high, spine; with the truncate, or slightly convex, summit expanded in the fore-and-aft direction, so as to touch the contiguous spines in the back; the spines are distinct in the tail. The sides of the base of the neural arch are thickened and extended outwards into 'diapophyses' having a convex articular surface for the attachment of the rib; the fore part is slightly produced at each angle into a zygapophysis looking upward and a little forward; the hinder part is much produced backwards, supporting two-thirds of the neural spine, and each angle is developed into a zygapophysis with a surface of opposite aspects to the anterior one. In the capsule of the notochord three bony plates are developed, one on the ventral surface, and one on each side, at or near the back part of the diapophysis. These bony plates may be termed 'cortical parts' of the centrum, in the same sense in which that term is applied to the element which is called 'body of the atlas' in Man and Mammalia, and 'sub-vertebral wedge-bone' at the fore part of the neck in Enaliosauria.

As such ventral or inferior cortical element co-exists with the separately ossified centrum in certain vertebræ of the *Ichthyosaurus*, thus affording ground for deeming them essentially distinct from a true centrum, I have applied the term 'hypapophysis' to such independent inferior ossifications in and from the notochordal capsule, and by that term may be signified the sub-notochordal plates in *Archegosaurus*, which co-exist with proper 'hæmapophyses' in the tail. In the trunk the hypapophyses are flat, subquadrate, oblong bodies, with the angles rounded off: in the tail they bend upwards by the extension of the ossification from the under- to the side-parts of the notochordal capsule, sometimes touching the lateral cortical plates. These serve to strengthen the notochord and support the intervertebral nerve in its outward passage.

The ribs are short, almost straight, expanded and flattened at the ends, round and slender at the middle. They are developed throughout the trunk and along part of the tail, coexisting there with the hæmal arches, as in the *Menopoma**.

The hæmal arches, which, at the beginning of the tail, are open at their base, become closed, in succeeding vertebræ, by extension of ossification inwards from each produced angle, converting the notch into a foramen. This forms a wide oval, the apex being produced into a long spine; but towards the end of the tail the spine becomes shortened, and the hæmal arch is reduced to a mere flattened ring. The size of the canal for the protection of the caudal blood-vessels indicates the powerful muscular actions of the long tail; as the produced spines, from both neural and hæmal arches, bespeak the provision made for muscular attachments, and the vertical development of the caudal swimming organ.

All these modifications of the vertebral column demonstrate the aquatic habits of the *Archegosaurus*; the limbs being, in like manner, modified as fins, but so small and feeble as to leave the main part of the function of swimming to be performed, as in fishes and Perennibranchiate Batrachia, by the tail.

The skull of the *Archegosaurus* appears to have retained much of its pri-

* Principal Forms of the Skeleton, 'Orr's Circle of the Sciences,' p. 187, fig. 11.

mary cartilage internally, and ossification to have been chiefly active at the surface, where, as in the combined dermo-neural ossifications of the skull in the sturgeons and salamandroid fishes, e. g. *Polypterus*, *Amia*, *Lepidosteus*, these ossifications have started from centres more numerous than those of the true vertebral system in the skull of Saurian reptiles.

The teeth are usually shed alternately; they consist of osteo-dentine, dentine, and cement. The first substance occupies the centre, the last covers the superficies of the tooth, but is introduced into its substance by many concentric folds extending along the basal half. These folds are indicated by fine longitudinal straight striæ along that half of the crown. The section of the tooth at that part gives the same structure which is shown by a like section of a tooth of the *Lepidosteus oxyurus**.

The same principle of dental composition is exemplified in the teeth of most of the ganoid fishes of the Carboniferous and Devonian systems, and is carried out to a great and beautiful degree of complication in the Old-red Dendrodonts.

The repetition of the same principle of dental structure in one of the earliest genera of *Reptilia*, associated with the defect of ossification of the endoskeleton and the excess of ossification in the exoskeleton of the head, decisively illustrate the true affinities and low position in the Reptilian class of the so-called *Archegosauri*.

For other details of the peculiar and interesting structure of the animals representing the earliest or oldest known order of Reptiles, the Reporter would refer to his article "Palæontology" in the 'Encyclopædia Britannica,' and to the works by Goldfuss and Von Meyer, above cited.

Order II. Labyrinthodontia.

This name, from λαβύρινθος, a labyrinth, and ὀδούς, a tooth, refers to the complex structure characterizing the teeth, in the several genera of the order; in which, also, the head is defended, as in the *Ganocephala*, by a continuous casque of externally sculptured and usually hard and polished osseous plates, including the supplementary 'postorbital' and 'supratemporal' bones, but leaving a 'foramen parietale†.' There are two occipital condyles. The vomer is divided and dentigerous. There are two external nostrils. The vertebral centra, as well as arches, are ossified, and are biconcave. The pleurapophyses of the trunk are long and bent. The teeth are rendered complex, at least at the basal part of the crown, by undulations and side-branches of the converging folds of cement; whence the name of the order.

The reptiles presenting the above characters have been divided, according to minor modifications exemplified by the form and proportions of the skull, by the relative position and size of the orbital, nasal, and temporal cavities, and by dermal characters, into several genera; as, e. g. *Mastodonsaurus*, *Anisopus*, *Trematosaurus*, *Metopias*, *Capitosaurus*, *Zygosaurus*, *Xestorrhytias*, &c.

The relation of these remarkable reptiles to the Saurian order has been advocated as being one of close and true affinity, chiefly on the character of the extent of ossification of the skull and of the outward sculpturing of the cranial bones. But the true nature of some of these bones appears to have been overlooked, and the gaze of research for analogous structures has been too exclusively upward. If directed downward from the *Labyrinthodontia* to the *Ganocephala*, and to certain ganoid fishes, it suggests other conclusions which I have developed in my article "Palæontology" above referred to.

* Wyman, 'American Journal of the Natural Sciences,' October, 1843.

† The corresponding vacuity is larger in some ganoid fishes.

There is nothing in the known structure of the so-named *Archegosaurus* or *Mastodonsaurus* that truly indicates a belonging to the Saurian or Crocodilian order of reptiles. The exterior ossifications of the skull and the canine-shaped labyrinthic teeth are both examples of the Salamandroid modification of the ganoid type of fishes.

The small proportion of the fore-limb of the *Mystriosaurus* in nowise illustrates this alleged saurian affinity, for, though it be as short as in *Archegosaurus*, it is as perfectly constructed as in the Crocodile; whereas the short fore limb of *Archegosaurus* is constructed after the simple type of that of the *Proteus* and *Siren*. But the futility of this argument of the sauroid affinities is made manifest by the proportions of the hind limb of *Archegosaurus*; it is as stunted as the fore limb: in the Labyrinthodonts it presented larger proportions, which, however, may be illustrated as naturally by these proportions in the limbs of certain *Batrachia* as by the proportions of the limbs of *Teleosaurus*.

Order III. Ichthyopterygia.

This name, from *ἰχθὺς*, a fish, and *πτέρυξ*, a wing or fin, relates to the piscin character of the numerous and many-jointed rays or digits in the fore and hind paddles. The bones of the head still include the supplementary 'post-orbital' and 'supratemporal' bones, but there are small temporal and other vacuities between the cranial bones, including a 'foramen parietale;' there is a single, convex, occipital condyle*; and one vomer, which is edentulous. There are two antorbital nostrils. The vertebral centra are ossified and biconcave. The pleurapophyses of the trunk are long and bent; the anterior ones with bifurcate heads. The teeth have converging folds of cement at their base, are implanted in a common alveolar groove, and are confined to the maxillary, premaxillary, and premandibular bones; the premaxillaries much exceeding the maxillaries in size. The orbits are very large; the eyes were defended by a broad circle of sclerotic plates. The limbs are natatory, with more than five multiarticulate digits; there is no sacrum.

With the retention of characters which indicate, as in the preceding orders, an affinity to the higher *Pisces Ganoidei*, the present exclusively marine *Reptilia* more directly exemplify the Ichthyic type in the proportions of the premaxillary and maxillary bones, in the shortness and great number of the biconcave vertebræ, in the length of the pleurapophyses of the vertebræ near the head, in the large proportional size of the eye-ball and its well-ossified sclerotic coat, and especially in the structure of the pectoral and ventral fins.

Order IV. Sauropterygia.

The fins in this order of marine reptiles do not include more than five digits and resemble those of the turtles (*Chelone*) amongst existing Reptiles; hence the name proposed, from *σαῦρος*, a lizard, and *πτέρυξ*. There are no post-orbital and supratemporal bones†: the skull shows large temporal and other vacuities between certain cranial bones, including a foramen parietale: there are two antorbital nostrils: the teeth are simple, in distinct sockets of the premaxillary, maxillary, and premandibular bones: they are very rarely present on the palatine or pterygoid bones. The maxillaries are larger than the premaxillaries. Limbs natatory; with not more than five digits. There is a sacrum of one or two vertebræ for the attachment of the pelvic arch in some: there are numerous cervical vertebræ in most. The pleurapophyses have simple heads; those of the trunk are long and bent.

* This character is retained in all the subsequent orders except the *Batrachia*.

† These bones do not reappear in the subsequent orders.

In the *Pliosaurus* the neck-vertebræ are comparatively few in number, short, and flat. The Sauropterygian type seems to have attained its maximum dimensions in this genus, the species of which are peculiar to the Oxfordian and Kimmeridgian divisions of the Upper Oolitic system. The Polyptychodon of the cretaceous series also attained a gigantic size.

M. von Meyer regards the number of cervical vertebræ and the length of neck as characters of prime importance in the classification of *Reptilia*, and founds thereon his order called '*Macrotrachelen*,' in which he includes *Simosaurus*, *Pistosaurus*, and *Nothosaurus* with *Plesiosaurus*. No doubt the number of vertebræ in the same skeleton bears a certain relation to ordinal groups: the *Ophidia* find a common character therein: yet it is not their essential character; for the snake-like form, dependent on multiplied vertebræ, characterizes equally certain batrachians (*Cæcilia*) and fishes (*Muræna*). Certain regions of the vertebral column are the seat of great varieties, in the same natural group of *Reptilia*. We have long-tailed and short-tailed Lizards; but do not, therefore, separate those with numerous caudal vertebræ as 'Macroura' from those with few or none. The extinct *Dolichosaurus* of the Kentish chalk, with its procœlian vertebræ, cannot be ordinally separated, by reason of its more numerous cervical vertebræ, from other shorter-necked procœlian lizards. As little can we separate the short-necked and big-headed amplicœlian Pliosaur from the 'Macrotrachelians' of von Meyer, with which it has its most intimate and true affinities.

There is much reason indeed to suspect that some of the Muschelkalk Saurians, which are as closely allied to *Nothosaurus* as *Pliosaurus* is to *Plesiosaurus*, may have presented analogous modifications in the number and proportions of the cervical vertebræ. It is hardly possible to contemplate the broad and short-snouted skull of the *Simosaurus*, with its proportionately large teeth, without inferring that such a head must have been supported by a shorter and more powerful neck than that which bore the long and slender head of the *Nothosaurus* or *Pistosaurus*. The like inference is more strongly impressed upon the mind by the skull of the *Placodus*, still shorter and broader than that of *Simosaurus*, and with vastly larger teeth, of a shape indicative of their adaptation to crushing molluscous or crustaceous shells.

Neither the proportions and armature of the skull of *Placodus*, nor the mode of obtaining the food indicated by its cranial and dental characters, permit the supposition that the head was supported by other than a comparatively short and strong neck. Yet the composition of the skull, its zygomata, temporal cavities, and other light-giving anatomical characters, all bespeak the close essential relationship of *Placodus* to *Simosaurus* and other so-called 'Macrotrachelian' reptiles of the Muschelkalk-beds. I continue, therefore, as in my former 'Report' of 1841, to regard the fin-like modification of the limbs as a better ordinal character than the number of vertebræ in any particular region of the spine. Yet this limb-character is subordinate to the characters derived from the structure of the skull and of the teeth. If, therefore, the general term *Enaliosauria* may be sometimes found convenient in its application to the natatory group of Saurian Reptiles, the essential distinctness of the orders *Sauropterygia* and *Ichthyopterygia*, typified by the *Ichthyosaurus* and *Plesiosaurus* respectively, should be borne in mind.

The *Plesiosaurus*, with its very numerous cervical vertebræ, sometimes thirty in number, may be regarded as the type of the *Sauropterygia* or pentadactyle sea-lizards. Of all existing Reptiles, the lizards, and amongst these the Old-world Monitors (*Varanus*, Fitz.), by reason of the cranial vacuities in front of the orbits, most resemble the Plesiosaur in the structure of the skull, the division of the nostrils, the vacuities in the occipital

region between the ex-occipitals and tympanics, the parietal foramen, the zygomatic extension of the post-frontal, the palato-maxillary and pterygo-sphenoid vacuities in the bony palate; and all these are Lacertian characters as contradistinguished from Crocodilian ones. But the antorbital vacuities between the nasal, pre-frontal, and maxillary bones, are the sole external nostrils in the Plesiosaurs: the zygomatic arch abuts against the fore part of the tympanic, and fixes it: a much greater extent of the roof of the mouth is ossified than in lizards, and the palato-maxillary and pterygosphenoid fissures are reduced to small size: the teeth, finally, are implanted in distinct sockets. That the Plesiosaur had the 'head of a lizard' is an emphatic mode of expressing the amount of resemblance in their cranial conformation: the crocodilian affinities, however, are not confined to the teeth, but are exemplified in some particulars of the structure of the skull itself.

In the simple mode of articulation of the ribs, the Lacertian affinity is again strongly manifested; but to this vertebral character such affinity is limited: all the others exemplify the ordinal distinction of the Plesiosaurs from known existing Reptiles. The shape of the joints of the centrums; the number of vertebræ between the head and tail, especially of those of the neck; the slight indication of the sacral vertebræ; the non-confluence of the caudal hæmapophyses with each other; are all 'plesiosauroid.' In the size and number of the abdominal ribs and sternum, may, perhaps, be discerned a first step in that series of development of the hæmapophyses of the trunk, which reaches its maximum in the plastron of the *Chelonia*.

The connation of the clavicle with the scapula is common to the *Chelonia* with the *Plesiosauri*; the expansion of the coracoid—extreme in *Plesiosauri*, —is greater in *Chelonia* than in *Crocodilia*, but is still greater in some *Lacertia*. The form and proportions of the pubis and ischium, as compared with the ilium, in the pelvic arch of the *Plesiosauri*, find their nearest approach in the pelvis of marine *Chelonia*; and no other existing Reptile now offers so near, although it be so remote, a resemblance to the structure of the paddles of the *Plesiosauri*.

Both *Nothosaurus* and *Pistosaurus* had many neck-vertebræ; and the transition from these to the dorsal series was effected, as in *Plesiosaurus*, by the ascent of the rib-surface from the centrum to the neurapophysis; but the surface, when divided between the two elements, projected further outwards than in most *Plesiosauri*.

In both *Notho-* and *Pisto-saurus*, the pelvic vertebra developes a combined process (par- and di-apophysis), but of relatively larger, vertically longer, size, standing well out, and from near the fore part of the side of the vertebra. This process, with the coalesced riblet, indicates a stronger ilium, and a firmer base of attachment of the hind limb to the trunk than in *Plesiosaurus*. Both this structure and the greater length of the bones of the fore-arm and leg show that the Muschelkalk predecessors of the Liassic *Plesiosauri* were better organized than they for occasional progression on dry land.

Order V. Anomodontia*.

This order is represented by three families, all the species of which are extinct, and appear to have been restricted to the Triassic period. In it the teeth are wanting, or are confluent with tusk-shaped premaxillaries, or are confined to a single pair in the upper jaw having the form and proportions of canine tusks. The skull shows a 'foramen parietale' and two nostrils: the tympanic pedicle is fixed. The vertebræ are biconcave: the pleurapophyses

* *ἄνομος*, lawless; *ὀδούς*, tooth.

of the trunk are long and curved, the anterior ones having bifurcate heads: there is a sacrum of four or five vertebræ, forming, with broad iliac and pubic bones, a large pelvis. Limbs ambulatory.

Family *Dicynodontia* *.

A long ever-growing tusk in each maxillary bone: premaxillaries connate and forming with the lower jaw a beak-shaped mouth, probably sheathed with horn. This family includes two genera, *Dicynodon* and *Ptychognathus*, all the known species of which are founded on fossils from rocks of probably triassic age in South Africa.

Family *Cryptodontia*†.

Upper as well as lower jaw edentulous. The genus *Oudenodon* closely conforms to the Dicynodont type, and the species are from the same rocks and localities.

Family *Gnathodontia*‡.

Two curved tusk-shaped bodies holding the place of the premaxillaries, and consisting of confluent dentinal and osseous substance, descending in front of the 'symphysis mandibulæ.' These bodies are homologous with the pair of confluent premaxillary teeth and bones in the existing New Zealand amphicœlian lizard *Rhynchocephalus*; they are analogous to the tusks in the *Dicynodonts*, and must have served a similar purpose in the extinct reptiles (*Rhynchosaurus*) of the New Red (Trias) Sandstone of Shropshire, in which alone, this structure, with an otherwise edentulous beak-shaped mouth, has hitherto been met with. The Rhynchosauroid reptile from the sandstone of Lossiemouth, near Elgin, is described by the Professor in the Government School of Mines, as having palatal teeth; but its close affinity to the Rhynchosaur of Shropshire adds to the probability of the triassic age of the Lossiemouth sandstone.

Order VI. Pterosauria§.

Although some members of the preceding order resembled birds in the shape or the edentulous state of the mouth, the reptiles of the present order make a closer approach to the feathered class in the texture and pneumatic character of most of the bones, and in the modification of the pectoral limbs for the function of flight. This is due to the elongation of the antibrachial bones, and more especially to the still greater length of the metacarpal and phalangial bones of the fifth or outermost digit, the last phalanx of which terminates in a point. The other fingers were of more ordinary length and size, and were terminated by claws, the number of their phalanges progressively increasing to the fourth, which had four joints. The whole osseous system is modified in accordance with the possession of wings: the bones are light, hollow, most of them permeated by air-cells, with thin, compact outer walls. The scapula and coracoid are long and narrow, but strong. The vertebræ of the neck are few, but large and strong, for the support of a large head with long jaws, armed with sharp-pointed teeth. The skull was lightened by large vacuities, of which one was interposed between the nostril and the orbit. The vertebræ of the back are small, as are those of the sacrum, which were from two to five in number, but combined with a small pelvis and weak hind limbs, bespeaking a creature unable to stand and walk like a bird: the body must have been dragged along the ground like that of a bat. The vertebral bodies were united by ball-and-socket joints, the cup being

* δὶς, twice; κυνόδους, canine-tooth.
† κρυπτὸς, concealed; ὀδοὺς, tooth.
‡ γνάθος, jaw; ὀδοὺς, tooth.
§ πτερὸν, wing; σαῦρος, lizard.

anterior; and in them we have the earliest manifestation of the 'procœlian' type of vertebra.

The Pterosauria are distributed into genera according to modifications of the jaws and teeth. In the oldest known species, from the Lias, the teeth are of two kinds; a few, at the fore part of the jaws, are long, large, sharp-pointed, with a full elliptical base, in distinct and separated sockets: behind them is a close-set row of short, compressed, very small, lancet-shaped teeth. These form the genus *Dimorphodon*, Ow.

In the genus *Rhamphorhynchus*, V. M., the fore part of each jaw is without teeth, and may have been encased by a horny beak; but behind the edentulous production there are four or five large and long teeth, on each side, followed by several smaller ones. The tail is long, stiff, and slender.

In the genus *Pterodactylus*, Cuv., the jaws are provided with teeth to their extremities: all the teeth are long, slender, sharp-pointed, set well apart. The tail is very short.

The *Pter. longirostris*, Ok., was about 10 inches in length; it is from lithographic slate at Pappenheim. The *Pter. crassirostris*, Goldf. was about 1 foot long; but the *Pter. Sedgwickii*, Ow., from the greensand, near Cambridge, had an expanse of wing of 20 feet. The above species exemplify the Pterodactyles proper.

The oldest well-known Pterodactyle is the *Dimorphodon macronyx*, of the lower lias; but bones of Pterodactyles have been discovered in coeval lias of Wirtemberg. The next in point of age is the *Dimorphodon Banthensis*, from the 'Posidonomyen-schiefer' of Banz in Bavaria, answering to the Alum-shale of the Whitby lias. Then follows the *Pt. Bucklandi* from the Stonesfield oolite. Above this, come the first-described and numerous species of Pterodactyle from the lithographic slates of the middle oolitic system, in Germany, and from Cirin on the Rhone. The Pterodactyles of the Wealden are, as yet, known to us by only a few bones and bone-fragments. The largest known species are the *Pterodactylus Sedgwickii* and *Pter. Fittoni*, from the Upper Greensand of Cambridgeshire. Finally, the Pterodactyles of the middle chalk of Kent, almost as remarkable for their great size, constitute the last forms of Flying Reptile known in the history of the crust of this earth.

Order VII. Thecodontia*.

The vertebral bodies are biconcave: the ribs of the trunk are long and bent, the anterior ones with a bifurcate head: the sacrum consists of three vertebræ: the limbs are ambulatory, and the femur has a third trochanter. The teeth have the crown more or less compressed, pointed, with trenchant and finely serrate margins; implanted in distinct sockets.

Teeth of this type, which may have belonged to the loricated saurian *Stagonolepis*, have been discovered by Mr. P. Duff in the white-sandstone at Lossiemouth near Elgin, affording additional evidence of its triassic age.

The *Protorosaurus* of the Permian Kupferschiefer of Thuringia appears to have had its teeth implanted in distinct sockets; but the neck-vertebræ resemble in their large and strong proportions those of the Pterodactyles; and the caudal vertebræ show the peculiarity, among Reptiles, of bifurcate neural spines. The types of the present order are the extinct genera *Thecodontosaurus* and *Palæosaurus* of Riley and Stutchbury, from probably triassic strata near Bristol; and the *Cladyodon* of the New Red sandstone of Warwickshire, with which, probably, the *Belodon* of the Keuper Sandstone of Wirtemberg is generically synonymous. The *Bathygnathus*, Leidy, from New Red sandstone of Prince Edward's Island, North America, is probably a

* θήκη, a case; ὀδούς, a tooth.

member of the present order, which seems to have been the forerunner of the next.

Order VIII. Dinosauria*.

Cervical and anterior dorsal vertebræ with par- and di-apophyses, articulating with bifurcate ribs: dorsal vertebræ with a neural platform: sacral vertebræ from four to six in number. The articular ends of the free vertebræ are more or less flat; but in the cervical become convex in front and concave behind, in some species. The limbs are ambulatory, strong, long and unguiculate. The femur has a third trochanter in some. The species of this order were of large bulk, and were eminently adapted for terrestrial life: some, *e. g.*, *Iguanodon* and probably *Hylæosaurus*, were more or less vegetable feeders; others, *e. g.*, *Megalosaurus*, were carnivorous. The Dinosaurs ranged, in time, from the lias (*Scelidosaurus*, Ow., from Charmouth) to the Upper Greensand (*Iguanodon*). The *Megalosaurus* occurs in the lower oolite to the Wealden inclusive. The latter formation is that in which the *Dinosauria* appear to have flourished in greatest numbers and of largest dimensions.

Order IX. Crocodilia.

Teeth in a single row, implanted in distinct sockets, external nostril single, and terminal or subterminal. Anterior trunk-vertebræ with par- and di-apophyses, and bifurcate ribs; sacral vertebræ two, each supporting its own neural arch. Skin protected by bony, usually pitted, plates.

Suborder *Amphicœlia*†.

Crocodiles closely resembling in general form the long- and slender-jawed kind of the Ganges, called Gavial, existed from the time of the deposition of the lower lias. Their teeth were similarly long, slender, and sharp, adapted for the prehension of fishes, and their skeleton was modified for more efficient progress in water, by both the terminal vertebral surfaces being slightly concave, by the hind limbs being relatively larger and stronger, and by the orbits forming no prominent obstruction to progress through water. From the nature of the deposits containing the remains of the so-modified Crocodiles, they were marine. The fossil Crocodile from the Whitby Lias, described and figured in the 'Philosophical Transactions,' 1758, p. 688, is the type of these amphicœlian species. They have been grouped under the following generic heads:—*Teleosaurus*, *Mystriosaurus*, *Macrospondylus*, *Massospondylus*, *Pelagosaurus*, *Æolodon*, *Suchosaurus*, *Goniopholis*, *Pœcilopleuron*, *Stagonolepis*, &c. Species of the above genera range from the lias to the chalk inclusive.

Suborder *Opisthocœlia*‡.

The small group of *Crocodilia*, so called, is an artificial one, based upon more or less of the anterior trunk-vertebræ being united by ball-and-socket joints, but having the ball in front, instead of, as in modern Crocodiles, behind. Cuvier first pointed out this peculiarity § in a crocodilian from the Oxfordian beds at Honfleur and the Kimmeridgian at Havre. The Reporter has described similar opisthocœlian vertebræ from the Great Oolite at Chipping Norton, from the Upper Lias of Whitby, and, of much larger size, from the Wealden formations of Sussex and the Isle of Wight. These specimens probably belonged, as suggested by him in 1841 and 1842‖, to the fore part

* δεινὸς, terrible; σαῦρος, lizard.
† ἀμφὶ, both; κοῖλος, hollow: the vertebræ being hollowed at both ends.
‡ ὄπισθε, behind; κοῖλος, hollow: vertebræ concave behind, convex in front.
§ Annales du Muséum, tom. xii. p. 83. pl. xxi.
‖ "Report on British Fossil Reptiles," Trans. British Association for 1841, p. 96.

of the same vertebral column as the vertebræ, flat at the fore part, and slightly hollow behind, on which he founded the genus *Cetiosaurus*. The smaller opisthocœlian vertebræ described by Cuvier have been referred by Von Meyer to a genus called *Streptospondylus*.

In one species of *Cetiosaurus* from the Wealden, dorsal vertebræ, measuring 8 inches across, are only 4 inches in length, and caudal vertebræ, nearly 7 inches across, are less than 4 inches in length; these characterize the species called *Cetiosaurus brevis*. Caudal vertebræ, measuring 7 inches across and $5\frac{1}{2}$ inches in length, from the Lower Oolite at Chipping Norton, and the Great Oolite at Enstone, represent the species called *Cetiosaurus medius*. Caudal vertebræ from the Portland Stone at Garsington, Oxfordshire, measuring 7 inches 9 lines across and 7 inches in length, have been referred to the *Cetiosaurus longus*; the latter appears to have been the most gigantic of Crocodilians.

Suborder *Procœlia**.

Crocodilians with cup-and-ball vertebræ like those of living species first make their appearance in the Greensand of North America (*Croc. basifissus* and *Croc. basitruncatus*)†. In Europe their remains are first found in the tertiary strata. Such remains from the plastic clay of Meudon have been referred to *Crocodilus isorhynchus*, *Croc. cœlorhynchus*, and *Croc. Becquereli*. In the 'Calcaire grossier' of Argenton and Castelnaudry have been found the *Croc. Rallinati* and *Croc. Dodunii*. In the coeval eocene London Clay at Sheppey Island, the entire skull and characteristic parts of the skeleton of *Crocodilus toliapicus* and *Croc. Champsoides* occur. In the somewhat later eocene beds at Bracklesham occur the remains of the Gavial-like *Croc. Dixoni*. In the Hordle upper eocene beds have been found the *Crocodilus Hastingsiæ* with short and broad jaws; and also a true Alligator (*Croc. Hantoniensis*). It is remarkable that forms of procœlian *Crocodilia*, now geographically restricted—the Gavial to Asia, and the Alligator to America,—should have been associated with true Crocodiles, and represented by species which lived during nearly the same geological period, in rivers flowing over what now forms the south coast of England.

Many species of procœlian *Crocodilia* have been founded on fossils from miocene and pliocene tertiaries. One of these, of the Gavial subgenus (*Croc. crassidens*) from the Sewalik tertiary, was of gigantic dimensions.

Order X. Lacertilia.

Vertebræ procœlian, with a single transverse process on each side, and with single-headed ribs: sacral vertebræ not exceeding two.

Small vertebræ of this type have been found in the Wealden of Sussex. They are more abundant, and are associated with other and more characteristic parts of the species in the Cretaceous strata. On such evidence have been based the *Raphiosaurus subulidens*, the *Coniosaurus crassidens*, and the *Dolichosaurus longicollis*. But the most remarkable and extreme modification of the Lacertian type in the Cretaceous period is that manifested by the huge species, of which a cranium, 5 feet long, was discovered in the Upper Chalk of St. Peter's Mount, near Maestricht, in 1780. This species, under the name *Mosasaurus*, is well known by the descriptions of Cuvier. Allied species have been found in the cretaceous strata of England and N. America. The *Leiodon anceps* of the Norfolk chalk was a nearly allied marine Lacertian. The structure of the limbs is not yet well understood; it may lead to a subordinal separation of the Mosasauroids from the Land-lizards, most of which

* πρὸ, before; κοῖλος, hollow: vertebræ with the cup at the fore part and the ball behind.

† Quarterly Journal of the Geological Society, January, 1849, p. 380.

are represented by existing species, in which a close transition is manifested to the next order.

Order XI. Ophidia *.

Vertebræ very numerous, procœlian, with a single transverse process on each side; no sacrum: no visible limbs.

The earliest evidence, at present, of this order is given by the fossil vertebræ of the large serpent (*Palæophis*, Ow.) from the London clay of Sheppey and Bracklesham. Remains of a poisonous serpent, apparently a *Vipera*, have been found in miocene deposits at Sansans, S. of France. A large fossil serpent (*Laophis*, Ow.), with vertebræ showing similar modifications to those in the Crotali, has been discovered by Capt. Sprat, R.N., in a tertiary formation at Salonica. Ophidiolites from Œningen have been referred to the genus *Coluber*.

Order XII. Chelonia †.

The characters of this order, including the extremely and peculiarly modified forms of Tortoises, Terrapenes, and Turtles, are sufficiently well known.

The chief modifications of osseous structure in oolitic Chelonia are shown by the additional pair of bones interposed between the hyosternals and hyposternals of the plastron, in the genus *Pleurosternon* from the upper oolite at Purbeck. It would be very hazardous to infer the existence of Reptiles with the characteristic structure of the restricted genus *Testudo* from the foot-prints in the triassic sandstone of Dumfriesshire. But the Reporter concurs in the general conclusions based upon the admirable figures and descriptions in the splendid monograph by Sir Wm. Jardine, Bart., F.L.S., that some of those foot-prints most probably belonged to species of the Chelonian order.

An enormous species of true turtle (*Chelone gigas*), the skull of which measured one foot across the back part, has left its remains in the eocene clay at Sheppey. The terrestrial type of the order had been exemplified on a still more gigantic scale by the *Colossochelys* of the Sewalik tertiaries.

Order XIII. Batrachia ‡.

Vertebræ biconcave (*Siren*), procœlian (*Rana*), or opisthocœlian (*Pipa*); pleurapophyses short, straight. Two occipital condyles and two vomerine bones, in most dentigerous: no scales or scutes. Larvæ with gills, in most deciduous. Representatives of existing families or genera of true Batrachia have been found fossil, chiefly in tertiary and post-tertiary strata. Indications of a perennibranchiate batrachian have recently been detected by the Reporter in a collection of minute Purbeck fossils. Anourous genera (*Palæophrynus*) allied to the Toad occur in the Œningen tertiaries, and here also the remains of the gigantic Salamander (*Andrias Scheuchzeri*) were discovered.

Summary of the above defined Orders.

Province VERTEBRATA.

Class Hæmatocrya. Sub-class Reptilia.

Orders.

I. Ganocephala.
II. Labyrinthodontia.
III. Ichthyopterygia.
IV. Sauropterygia.
V. Anomodontia.
VI. Pterosauria.
VII. Thecodontia.
VIII. Dinosauria.
IX. Crocodilia.
X. Lacertilia.
XI. Ophidia.
XII. Chelonia.
XIII. Batrachia.

* ὄφις, a serpent. † χελώνη, a tortoise. ‡ βάτραχος, a frog.