CRETACEOUS LIZARDS.

173
to light the modifications of the head and limbs of the Protemys: from those of the plastron we may infer that the species was more aquatic in its habits than the typical Emydians. The Protemys serrata may have been an Estuary species, and its discovery in the same formation and quarry as that in which the remains of an Iguanodon have been found, adds probability to the explanation of the occurrence of the latter in a Green-sand or Neocomian Deposit, on the supposition that the carcase had been drifted out to sea.

CHAPTER II.

ORDER, LACERTILIA.

LIZARDS.

In passing from the Tertiary to the Secondary periods of Geology, in quest of the evidences of Reptilian organisation, we have found no material change in that of the Chelonian order; the characters by which the marine species are now generically separated from other Testudines of Linnæus, and which were not deemed worthy of that distinction by the great systematic reformer of Natural History, are recognisably retained in the old Turtles, the contemporaries of the Ichthyosaurs, Plesiosaurs, Pterodactyles, and Belemnites, that swam the ocean in which the Corals and Sponges lived, which deposited the main part of the material that now constitutes our Chalk Downs. The differences which are traceable on a comparison of the Turtles of that period with those of the Tertiary deposits and of the actual seas, merely prove them to have been distinct species, with some slight indications of a nearer affinity to the Emydian type of structure than we observe in the present representatives of the genus Chelone.

The Lizards of the present day are characterised, with the exception of one genus, Gecko, by the same cup-and-ball articulation of the vertebrae as the modern Crocodiles, viz. with the cup at the fore part of the body of the vertebra and the ball at the back part, an arrangement signified by the term “procoelian,” as applied to such vertebrae. The fossil Lizards of the Cretaceous period, whether terrestrial, amphibious, or more especially modified for marine life, present the same procoelian type.

Tribe, Repentia.

Genus, Raphiosaurus, Owen.

‘Transactions of the Geological Society,’ vol. vi, 2d Series, p. 413, April, 1840.

Species, Raphiosaurus subulidens, Owen, (Plate 9, figs. 1, 2, 3.)


In a Memoir communicated to the Geological Society of London in 1840, and in
my 'Report on British Fossil Reptiles,' published in the volume of 'Reports of the British Association' for 1841, p. 145, I proposed the name of *Raphiosaurus* for a genus of small extinct lacertine *Sauria*, characterised by slender awl-shaped teeth, attached by ankylosis in a single series to the bottom of a shallow alveolar groove, and to the inner side of an outer wall or parapet of the same groove; thus corresponding with that type of saurian dentition called 'pleurodont' amongst modern Lizards.†

The specimen figured in Pl. 9, figs. 1, 2, 3, on which that genus was founded, was discovered in the Lower Chalk near Cambridge, and forms part of the rich collection illustrative of the Cretaceous Formations of Cambridgeshire, in the possession of James Carter, Esq., M.R.C.S., to whose kindness I am indebted for the opportunity of describing the specimen. It consists of a considerable portion of the dentary part of the lower jaw, and contains twenty-two of the above-described teeth, arranged in a close series: in fig. 2 some teeth are shown in place; in fig. 3, a and b show teeth with the crown broken off; and c is the groove or incomplete socket of a shed tooth.

At the period when this fossil was described,‡ the only vertebrae of a lacertine Saurian, which at all approximated to the proportions of the species indicated by the jaw and teeth of the *Raphiosaurus*, were those which Sir Philip de M. Grey Egerton, Bart., had kindly submitted to my inspection, and which are figured in the volume of the 'Geological Society's Transactions' already cited.§ That chain of vertebrae was discovered in the lower chalk of Kent, at Burham pit, and manifested specific distinctions from the vertebrae of the existing genera of Lacertians, with which I was able to compare them in 1840; and at that time I could only suggest, when pressed for a closer determination, that, on the hypothesis of their having belonged to the same species as the fossil Lacertian from the Cambridge Chalk, they must be referred to a Lizard generically distinct from any known existing species. Other specimens with which my lamented friend Mr. Dixon subsequently supplied me, have rendered it highly probable that the vertebrae (figured in Pl. 9, fig. 4) belonged to an extinct Lizard, distinct from the Cambridge *Raphiosaurus*, with the vertebral characters of which species we are still, therefore, unacquainted.

I have been favoured, by W. H. Bristow, Esq., with the inspection of portions, about one inch and a half in length, of the upper and lower jaws of a Lizard; the rami of the lower jaw being a third of an inch in depth, with long, slender, awl-shaped teeth, answering to those of the *Raphiosaurus*. There were five of these teeth fully formed in the portion of the upper jaw, with intervening small ones in the course of development. The portion of lower jaw had three or four irregular rows of small apertures opening on its outer side. These specimens were found in the chalk at Northfleet.

* From *ραφίως*, an awl; *σαυρός*, a lizard.  
† Odontography, 4to, p. 182.  
§ Ib. p. 413, pl. 39, fig. 3.
CRETACEOUS LIZARDS.

Genus, Coniosaurus,* Owen.

Species, Coniosaurus crassidens. (Pl. 2, figs. 18, 19, 19a, and 20.)

Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex,' 4to, p. 386.

Two genera of Lizards of the Cretaceous period, with procælian cup-and-ball vertebrae, similar in size and form to those of the series figured and described in the 'Geological Transactions,' vol. vi, 2d ser., pl. 39, fig. 3, are now no longer hypothetical, but have been satisfactorily established by the discovery of portions of jaws and teeth associated with such vertebrae. The first of these specimens, which discloses a small extinct Lacertian, distinct from Raphiosaurus, and characteristic of the chalk formation, was obtained from the Middle Chalk at Clayton, Sussex, and forms part of the choice and instructive collection of Henry Catt, Esq., of Brighton. It is figured in 'Lacertians,' Pl. 2, figs. 19 and 20, and a group of vertebrae of apparently the same species is represented in fig. 19.

These vertebrae are represented of the natural size. Like those first figured in the 'Geological Transactions,' tom. cit., pl. 39, they present an anterior concavity or cup, and a posterior ball upon the bodies for their reciprocal articulation; and a tubercle is developed from each side of the vertebral body near its anterior end, for the articulation of the rib. The non-articular surface of the vertebra is smooth; its under part is concave in the axis of the body, convex transversely. On the very probable supposition, however, that the vertebra, v, fig. 19, belonged to the same animal as the jaw which is imbedded in the same portion of chalk, such vertebrae must be smaller in proportion to the head than in the extinct species of Lacertine Saurian, Pl. 8, fig. 1, likewise from the chalk, and to which there will be adduced reasons for believing that the fine specimen, in the collection of Sir P. de M. Grey Egerton, Bart. (Pl. 9, fig. 4), belongs. The fossil jaw and teeth in Pl. 2, fig. 19, determine the distinctness of the Coniosaurus from the above-named fossil, as well as from all known recent Lizards.

The dentary bone contains from eighteen to twenty teeth; the anterior five or six teeth are slender, slightly recurved, pointed, or laniariform; the rest progressively increase in thickness as they are placed further back; expanding above the neck, slightly compressed laterally, most convex inwardly, with an anterior border, which is more prominent and curved than the posterior one: the anterior margin is further characterised by a longitudinal groove on its outer side. Some of the posterior teeth show a slight longitudinal indent near the posterior obtuse border; the last molar is smaller and more obtuse than the others. The enamel is very finely wrinkled. The teeth are closely and rather obliquely arranged; the long simple roots are anchylosed to the bottom of the shallow alveolar groove, and to the inner side of the outer wall,

* Κονιοσαύρος, chalk; σαῦρος, lizard.
and their excavations indicate the usual mode of succession and displacement: a few alternate teeth have been shed.

The mode of attachment more resembles that which characterises the teeth in *Lacerta* proper and other "cœlodont" genera of the Lacertian tribe; but in the number, proportions, and general shape of the teeth, the present species more resembles some of the Iguanian tribe. The anterior coronal groove is continued to the anterior margin of the crown, which it slightly indents in the larger teeth; but this is the only approach to that complex structure which characterises the teeth of the typical *Iguanidae*. Pl. 2, fig. 19 a is a magnified view of the crown of one of the anterior teeth; and fig. 19 a' of one of the posterior teeth.

There is no existing species of the Iguanian or other herbivorous family, nor of any of the 'pleurodont' Saurians, with which the present chalk-fossil is identical; nor can I refer it to any of the established genera of *Lacertilia*. The absence of the cranium and bones of the extremities, does not allow of any closer comparison with the Monitors, Iguanas, or Scinks; but the characters of the teeth justify the consideration of the fossil as the type of a hitherto undescribed genus and species, which I therefore propose to call *Coniosaurus crassidens*, or the thick-toothed Lizard of the Chalk formation.

The specimens represented in figs. 18, 19, and 20, are from the Clayton chalk-pit near Brighton: a smaller portion of a lower jaw and a few teeth have been obtained by Mr. Dixon from the Washington chalk-pit near Worthing: and vertebrae have been found by Mr. Catt in the upper chalk near Falmer, during the cutting of the railroad from Brighton to Lewes. These are the only specimens of the genus and species that have yet been discovered.

*Genus, Dolichosaurus,* *Owen.*


Species, *Dolichosaurus longicollis.* (Plate 8, figs. 1 and 2.)

My esteemed friend the late Frederic Dixon, Esq., F.G.S., in the course of his indefatigable inquiries respecting the fossils of the cretaceous period, obtained such information relative to the unique specimen of the mutilated head and anterior thirty-six vertebrae of the fossil Lizard from the lower chalk of Kent, in the admirable collection of Mrs. Smith of Tunbridge Wells, figured in Pl. 8, fig. 1, as left no doubt in his mind that it formed part of the same skeleton with the chain of posterior abdominal and sacral vertebrae in the collection of Sir P. de M. Grey Egerton, Bart., M.P., F.G.S., and which is figured in the 'Geological Transactions,' 2d Series, vol. vi, pl. 39; and in the present work at Pl. 9, fig. 4.

*Δολίχος, long, σαυρος, lizard.*
Both specimens are from the same quarry or pit at Burham, in Kent, were found at the same time, and there is good reason to suppose in the same block of chalk. It appears, however, that they were disposed of by the quarrymen to different persons, and ultimately found their way to the two collections of which they are now respectively the ornaments.

Assuming, then, the two groups of vertebrae to have belonged to the same skeleton, and the conformity in shape and size of the vertebrae and ribs favours the conclusion which Mr. Dixon had drawn from the historical evidence, we may then enumerate fifty-seven vertebrae between the skull and the pelvis, supposing that none have been lost between the end of the specimen in Pl. 8, fig. 1, and the beginning of that in Pl. 9, fig. 4. Amongst existing Lizards this number of trunk (cervical, dorsal, and lumbar) vertebrae is equalled only by those snake-like species (Pseudopus, Bipes, Ophisaurus) which seem to make the transition from the Lacertian to the Ophidian reptiles: but not any of such genera manifest so well-developed a humerus and scapular arch as are indicated in Pl. 8, fig. 1, or so complete a sacrum and pelvic bones as are shown in Pl. 9, fig. 4. Of those existing Lacertians which had the hinder extremities as well developed as in the extinct species under consideration, the greatest recorded number of vertebrae between the skull and the sacrum is forty-one.*

Although the evidence relating to the discovery of the specimens (Pl. 9, fig. 4, and Pl. 8, fig. 1) is such as to lead me to deem it highly probable that they form the anterior and posterior moieties of the backbone of the same individual; yet, as it does not amount to absolute demonstration, the characters of the Saurian in question must for the present be rigorously deduced from those parts which are unaffected by such uncertainty. In this fit condition for scientific comparison must be regarded the fragment of skull, and the chain of thirty-six vertebrae imbedded in one block of chalk, and represented in Pl. 8, fig. 1. The most cautious and sceptical Palæontologist must admit, after scrupulous examination of the specimen, that the jaws and the portion of vertebral column, which are accurately figured in the plate, have belonged to one and the same animal, having been subject to no greater amount of dislocation than is represented at the twenty-fifth vertebra for example, and in the position of some of the ribs. Viewing the slight extent of displacement of any of these parts in the fossil, it is very improbable that the scapular arch should have been subjected to any considerably greater degree of displacement; and taking, also, into consideration the gradual diminution of the vertebrae, as they extend forwards from the place of the scapular arch in the fossil, at the eighteenth or twentieth vertebrae, to the cranium, and the remarkable and striking difference in the shape and size of the pleurapophyses (vertebral ribs, pl., pl.) in those anterior vertebrae, I am led to conclude that the position of the remains of the scapular arch in the fossil was, in relation to the vertebral

* According to the table in Cuvier, Leçons d’Anat. Comp. i (1836), p. 221, e. g. in the Scincus ocellatus.
column, its true position in the skeleton of the living reptile, and that the vertebrae anterior to it answer to those which are called cervical by Cuvier, in the existing lizards which have four well-developed extremities.

The artificial character of the 'cervical' vertebrae of anatomy is more obvious in the Lacertine Sauria than in most other vertebrates. Cuvier, who has assigned the precise number of such vertebrae to several species of Lacertians, in his 'Table of the Vertebrae of Reptiles,* does not define their characters. He merely observes that "they have inferior crests like the anterior dorsal vertebrae."†

With regard to the Monitor (Varanus) Cuvier affirms, in another work,‡ that the "inferior crest distinguishes the cervical from the dorsal vertebrae;" but he admits that the first three of these dorsal vertebrae have an inferior tubercle. Proceeding next to speak of the American Monitor (Monitor proper, or Tejus) he says,—"Les vertébres cervicales, déterminées par les fausses côtes antérieures, sont au nombre de huit, c'est-à-dire qu'il y a six paires de ces fausses côtes."§ This number of so-defined cervicals is found in the Iguanians, Basilisc, true Lizards, Gecko, Anolises, Agamians and Stellios. But Cuvier admits that two if not three of the last of these cervical vertebrae, although their false ribs (pleurapophyses) do not reach the sternum, are embraced by the scapular arch, and concur in the formation of the chest: if these be accordingly subtracted, the number of cervicals will be reduced, Cuvier says, to five. In the 'Table of Vertebrae' above cited, only four cervicals are allowed to the Iguana, Basilisc, the banded Gecko, Anolitis, Agama, and the Levantine Stellio. There is a difference, however, in the number assigned to some of these species in the table in the 'Ossemens Fossiles.'|| But all these discrepancies depend on the inconsistent characters that hitherto have been assigned to the cervical vertebrae of Lizards.

Recognising the artificial nature of such a group of vertebrae, I believe that their character, which must needs be arbitrary, would be most easily determined, and, therefore, most convenient in its application, which should be founded on the absence of sternal ribs (haemapophyses): according to which character the vertebra that first was joined to the sternum by sternal ribs would be reckoned as the first "dorsal," and all anterior to it as "cervical vertebrae." This arbitrary character would agree with that by which the cervical vertebrae are, in point of fact, defined in the human subject and mammalia generally.

In the fossil Lacertian, however, which forms the more immediate subject of this description, there is no indication of a junction of the vertebral rib (pleurapophysis) by a sternal rib (haemapophysis) with a sternum (haemal spine), and I can only compare the cervical region of the spine with that in existing Lacertians, in so far as relates to

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* Leçons d'Anat. Comp. i. (1835,) p. 220.
† Ib. p. 215.
‡ Ossemens Fossiles, 4to, v, pt. ii, p. 284.
the vertebrae situated between the skull and the scapular arch. The number of vertebrae so situated in modern Lacertians is usually five, and rarely exceeds six: in the Dolichosaurus it was seventeen. In modern Lacertians the bodies and neural arches of such cervicals are scarcely inferior in breadth to the succeeding vertebrae, and commonly surpass them in depth by reason of the largely developed inferior spinous processes. The short anterior pleurapophyses are usually thick, broad, and expanded at their extremities, or are “hatchet-shaped” (Cyclodus, Tiliqua, Scincus). Besides the superior number of the cervical vertebrae in the Dolichosaurus, they exhibit a more decided decrease of size as they approach the head: the pleurapophysis of the third or fourth vertebra is short, almost straight, and very slender: that of the eighth or ninth vertebra is also very slender, and but a little longer: those of the three succeeding vertebrae progressively, though slightly, increase in length, but the vertebral ribs do not exhibit their normal length until the seventeenth or eighteenth vertebra: the pleurapophysial character of these eighteen or twenty anterior vertebrae is much more like that of the same vertebrae in the Ophidian than in the existing Lacertian reptiles: and there is no trace of any of the vertebral ribs having supported sternal ribs, or having been attached by these to a sternum. The slender anterior ribs increase in length, however, more gradually in the Dolichosaurus than in Serpents.

The occipital region of the fossil skull, with the atlas and dentata, have been too much crushed to allow of their structure being accurately determined and compared: the first tolerably entire vertebra appears to be the fourth from the head: the expanded back part of the neural arch receives the contracted fore part of that arch of the fifth vertebra: the base of the neural spine is slightly expanded posteriorly. In the fifth and succeeding vertebrae, the anterior articular processes look upwards, the posterior ones downwards, and they are simple as in ordinary Lizards, but rather longer and more slender. The thin base of the neural spine extends along the middle of the summit of the entire arch; the sides of which slope downwards and outwards more gradually, i. e. do not curve outwards so suddenly as in the Iguana and Cyclodus. The short convex diapophysis (d) supporting the rib is developed from the side of the fore part of the centrum beneath and a little behind the anterior zygapophysis. I excavated the chalk beneath the seventh vertebra, and exposed a short compressed ‘hypapophysis,’ or inferior spine projecting downwards from the middle of the hinder half of the centrum. The ribs are hollow, as in the Cyclodus* and in Ophidians. The long pleurapophyses of the twentieth and succeeding vertebrae are more compressed than in the Iguana and Cyclodus: they are less regularly or gradually curved: the comparatively straight middle portion after the first slight bend is too constant in the ribs of the fossil not to be natural: this shape of the ribs indicates the abdomen to have been

* The vertebral ribs (pleurapophyses) are probably hollow in other Lacertians, but I cite only the genus in which I have found them so in the present comparison.
more compressed, as the number of vertebrae shows it to have been longer than in the *Iguana* or *Cyclodus*. The twenty-sixth vertebra is dislocated: the two following are turned upon their side and expose the under part: here the inferior spine has disappeared: the surface is smooth, slightly punctate, gently concave lengthwise, convex transversely. Figure 2, Pl. 8, gives a direct side view of the best-preserved ramus (the left) of the jaw: below, in outline, of the natural size; above, magnified. The extent and upward curve of the coronoid piece most resembles that in the *Varanus* (Cuvier, loc. cit. pl. 16, fig. 8 c); but in this genus it is relatively shorter than in the *Dolichosaurus*, and in other recent Lacertians it is still shorter and more pyramidal in shape. The extent of the surangular, and its length behind the coronoid, are Lacertian characters: but the outer surface is divided by a longitudinal ridge or angle into an upper and a lower facet, the upper one being slightly excavated: the enamelled crowns of the last four teeth show a simple obtuse shape; they are chiefly remarkable for their small proportional size. The two dentary bones meet at an acute angle; that on the right side joins a surangular piece which is continued back to near the articular surface. Allowing a symphysis of the ordinary lacertian proportions, the length of the under jaw may be estimated to have been four centimeters (one inch seven lines), or equal to between four and five dorsal vertebrae. One of the vertical columnelliform bones is preserved on the left side of the cranium.

Parallel with the eighteenth, nineteenth, and twentieth vertebrae lie the remains of a broad, thin, and flat bone, with a smooth emargination, and a rough or slightly granulated surface. As the broad, thin, and anteriorly emarginate scapula of the Iguana presents a similar surface, I conclude this part in the fossil to be scapula; and the short, thick, subcylindrical, hollow bone, behind it, which is slightly twisted and expanded at both ends, to be the shaft of the humerus: it is shorter in proportion to its breadth than in the existing Lizards, and probably supported a shorter fore-arm and fore-foot; the whole limb being therefore perhaps more formed for swimming than in the Monitors and Iguanæ.

The ball-and-socket structure of the vertebrae is better adapted to sustain the body on dry land than the biconcave structure; but the modern Crocodiles, the Amblyrhynchus or marine lizard of the Gallopagos Islands, the Salamander, and even the Lepidosteus amongst fishes, prove it not to be incompatible with aquatic habits. The *Dolichosaurus*, with a procoelian type of vertebrate structure, and amongst the earliest reptiles that manifested such structure, may well have been a good swimmer and frequenter of the ancient ocean of its epoch, as well as a crawler on dry land. Although the articulations of the vertebrae must have limited if not prohibited rotation or inflection of the spine in the vertical direction, the extent of lateral flexuosity is considerable; the double curve of the fore part of the vertebral column, preserved in Pl. 8, fig. 1, being, if not the natural one assumed in the last struggles of the dying
animal, that which the vertebral joint freely allowed in the dead carcase before it became fixed in the chalk-mud.

Assuming that the specimens Pl. 8, fig. 1 and Pl. 9, fig. 4, give the natural length of the neck and trunk of the *Dolichosaurus*, to which trunk the size of the anterior caudal vertebrae indicate a long and strong tail to have been appended, the progress of the long and slender *Dolichosaurus* through the water would be by flexuous and undulatory lateral movements of the entire body, like those of a water-snake or eel.

The specimen Pl. 8, fig. 1, demonstrates that this procoelian Lizard of the cretaceous period had a smaller head, and a longer, more slender, and tapering neck, than any known existing species of the Lacertian order of Reptiles.

The hinder moiety of the trunk-vertebrae, with part of the pelvis and root of the tail, Pl. 9, fig. 4,—which, from the correspondence of size, shape and structure of the vertebrae, I refer to the *Dolichosaurus*, and from the evidence above given, corroborated by the disposition of the parts in the chalk-matrix, I believe to be part of the same skeleton as the anterior moiety, Pl. 8, fig. 1,—includes twenty-one abdominal, two sacral, and five caudal vertebrae. They have been exposed by the removal of the chalk from their inferior or ventral surfaces, the operation having been commenced from the opposite side of the block from that at which the exposure of the part of the skeleton in the other portion of the same block of chalk has been effected. The bodies of the vertebrae and the ribs show the same disposition and slight degree of dislocation as in the specimen. The ribs have been pressed by the weight of the surrounding chalk, as the soft parts yielded and became decomposed, close to the sides of the vertebrae, but with scarcely any further dislocation; and the vertebrae, maintaining the close articulations of their cup-and-ball surfaces, continue, with not more deviation from the straight line than a slight flexuosity, like that shown by the last six vertebrae in the moiety of the skeleton in Pl. 8, fig. 1.

The under surfaces of the vertebrae exhibit the same smooth, imperforate, longitudinally concave, transversely convex surfaces, as in the anterior dorsals of the last-described specimen: as in that specimen, also, they are longer in proportion to their breadth than in the Monitor (*Varanus* ?) figured by Cuvier,* or than in the *Iguana, Cyclodus* and *Tiliqua*: the diapophyses rise by a shorter base than in the *Iguana*: in an Australian *Tiliqua* I find the under surface of the centrum with two vascular perforations towards its fore part, which are not present in the *Dolichosaurus*, nor in many of the existing Lacertians. Each diapophysis forms a short rounded tubercle, immediately below the base of the anterior zygapophysis; and the simple, slightly expanded head of the rib is excavated to fit the tubercle. In the degree of compression and expansion of the proximal portions of the ribs, and in their curvature, the present precisely corresponds with the preceding portion of the skeleton of the *Dolichosaurus*; and it is

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* Ossem. Foss., v, pt. ii, pl. 17, fig. 23.
obvious that the natural form of the abdomen must have been deep and narrow, like that of the Water-Snakes (Hydrophides).

The length of the last two abdominal vertebrae slightly decreases: a short, slender, nearly straight and pointed pleurapophysis projects outwards from the diapophysis of the last abdominal (lumbar) vertebra with which it has become anchylosed. The pleurapophyses of the next two vertebrae are equally confluent with the diapophyses, but are rather longer and much thicker than those of the preceding vertebra: they are also slightly expanded and truncate at their ends; they determine by these proportions the ‘sacral vertebra,’ which thus agree in number, as in general structure, in the Dolichosaurus with those in existing Lacertians.

Part of the bodies of the two sacral vertebrae has been destroyed, but evident traces of the persistent cup-and-ball articulation between them remain. In the Scincoids the bodies of the sacral vertebrae become anchylosed together. The extremities of the sacral pleurapophyses come into contact in the Dolichosaurus, but do not coalesce: the second sacral vertebra presents a ball to the first caudal, as in existing Lacertians, not a cup, as in the modern Crocodilia. On the right side of the specimen the hinder half of the iliac bone extends backwards, projecting freely a short way behind the second sacral pleurapophysis, as in some modern Lacertians (Cyclodus, e. g.). On the left side a part of the ilium is preserved, which extends to the acetabulum. A portion of the expanded ischium is likewise preserved, and the distal half of the left femur extends back in a right line from the position of the hip-joint. The length of the entire femur could not have exceeded three centimeters, or fourteen lines; it thus agrees in its relative shortness with the humerus in fig. 1, 53, and accords with the idea that the Dolichosaurus was more aquatic in its habits than the modern Lacertians, most of which have longer proportional humeri and femora. The femur of the Dolichosaurus had a medullary cavity. The under surface of the first two caudal vertebrae is impressed by a median, longitudinal, shallow canal, bounded by two slight ridges, diverging posteriorly in the second caudal to the tubercles (hypapophyses) that have supported the hæmal arch; these tubercles are close to the posterior articulation. A part of the spine of this hæmal arch is preserved nearly in its true position.

The foregoing comparisons show that all the general characters of the Lacertian type of the vertebrate skeleton are presented by the Dolichosaurus: they are most modified in the cervical region, where the Ophidian type is rather followed in the number and size of the vertebrae, and in the size and shape of the ribs: a less decided approach, but one still indicating an affinity to the Ophidians, is made by the unusual length of the slender trunk, which includes, from the skull to the sacrum, not fewer than fifty-seven vertebrae, and is not less than eighteen inches in length. The smallness of the head accords with the long and slender proportions of the neck, and must have added to the snake-like appearance of this early example of procoelian lizard. But the complete and typically Lacertian organisation of the scapular and pelvic arches, and
of their locomotive appendages, prove that the *Dolichosaurus* was more strictly a lacerteine Saurian than the existing genera, *Pseudopus*, *Bipes* and *Ophisaurus*, which effect the transition from the Lizards to the Snakes.

**Tribe, Natantia.**

**Genus, Mosasaurus.**

The history of the discovery by Major Drouin, in 1766, of the gigantic marine lizard called by Conybeare *Mosasaurus*, together with an account of the nature of the formation in which its remains occur, arc fully given by Cuvier, in his 'Recherches sur les Ossemens Fossiles,' tom. v, pt. ii, pp. 310—320. The largest species of *Mosasaurus* is calculated to have been at least twenty-five feet in length, and derives its name from the locality on the banks of the Meuse, near Maestricht, where the newer cretaceous deposits occur in which its remains were found. The finest and most perfect skull of the animal was discovered in the quarries at St. Peter's Mount. Camper saw it in 1785, in the house of the Rev. Dr. Goddin, canon of the chapter of Maestricht, and writes:—"In this the greater part of both the upper and under maxillary bones is entire, and a bone, with small teeth, belonging to the palate; by which it appears, the animal had not only teeth in the jaw-bones, but also in the throat, as several fishes have, but which are never found in the mouth of crocodiles;"* and Camper naively expresses his surprise that notwithstanding all his endeavours to convince his friends, he "never could prevail upon them to adopt his opinion, that these bones belonged to the physeteres or respiring fishes." In fact, neither the physeter nor any other cetacean or respiring fish, have teeth on the palate any more than the crocodiles. M. Adrien Camper, the son of the great anatomist, first pointed out the affinities of the Mosasaurus to the *Monitors* and *Iguana,†* in which latter genus, as in *Amblyrhynchus*, small teeth are present on the same bones, viz., the pterygoid, in which they occur in the Mosasaurus. The large fossil skull of the Mosasaurus was yielded up by the Canon Goddin to the French army, after the capture of Maestricht by the forces of the Republic in 1795, and it was transported to the Museum of the Garden of Plants at Paris, where it still remains. M. Faujas St. Fond, who, in his capacity as Commissary for the Sciences of the "Army of the North," transacted the transfer of the famous specimen, gives the following account of its discovery:—

*Philosophical Transactions, 1786, p. 444.*

† In a letter to M. Cuvier, in the 'Bulletin de la Société Philomathique,' Fructidor, An. viii (1790); and in the 'Journal de Physique,' Vendémiaire, An. ix (1791). See also his 'Mémoire sur quelques parties moins connues du squelette des Sauriens Fossiles de Maestricht,' in the 'Annales du Muséum d'Hist. Nat.,' tom. xix (1812), p. 215.
"In one of the great galleries or subterraneous quarries in which the cretaceous stone of St. Peter's Mount is worked, about five hundred paces from the entrance, and ninety feet below the surface, the quarry-men exposed part of the skull of a large animal in a block of the stone which they were engaged in detaching. On this discovery they suspended their work, and went to inform Dr. Hoffmann, surgeon to the forces at Maestricht, who for some years had been collecting the fossils from this quarry, remunerating the workmen liberally for the discovery and preservation of them. Dr. Hoffmann, arriving at the spot, saw with extreme pleasure the indications of a magnificent specimen; he directed the operations of the men, so that they worked out the block without injury to the fossil, and he then with his own hands cleared away, by degrees, the yielding matrix, and exposed the extraordinary jaws and teeth, which have since been the subject of so many drawings, descriptions, and discussions. This fine specimen which Hoffmann had transported with so much satisfaction to his collection, soon, however, became a source of much chagrin to him. Dr. Goddin, one of the canons of Maestricht, who owned the surface of the soil beneath which was the quarry whence the fossil had been obtained, when the fame of the specimen reached his ears, pleaded certain feudal rights in support of his claim to it. Hoffmann resisted, and the canon went to law. The whole chapter supported their reverend brother, and the decree ultimately went against the poor surgeon, who lost both his specimen and his money, for he was made to pay the costs of the action." M. Faujas St. Fond, the instrument of the more forcible and summary mode by which the French seized upon the unique specimen, moralizes in his narrative of the robbery in the following strain:—"The canon Goddin, leaving all remorse to the judges who had pronounced the iniquitous sentence, became the happy and contented possessor of this unique example of its kind. But justice, though tardy, comes at last." M. Faujas then proceeds to narrate how, in the bombardment of the town, directions were given to spare the suburb in which the famous fossil was understood to be preserved; and how, after the capitulation, the French grenadiers discovered, seized, and bore off the specimen in triumph to the commissarial residence; and concludes by a pæan to the "excellent soldiers who always knew how to appreciate and respect the monuments of the arts and sciences."  

The occurrence of remains of the *Mosasaurus* in England was first noticed by Dr. Mantell, in a work entitled 'The Geology of the South-east of England," 8vo, 1833, in which woodcuts are given at p. 146, of a dorsal vertebra, and of two caudal vertebrae, which were found in the upper (?) chalk, near Lewes. The body of the dorsal vertebra is said to be "about two inches long, and 1'4 inch high;" and the

* First by Buchoz, in his 'Dons de la Nature,' tab. 68; then by Faujas St. Fond, in plate iv of his 'Histoire Naturelle de la Montagne de St. Pierre;' afterwards by Cuvier, in his 'Ossements Fossiles,' tom. v, pt. ii, pl. xviii; copied by Buckland in the 'Bridgewater Treatise,' pl. 20.

† Tom. cit., p. 62.
mutilated body of a vertebra of these dimensions, together with the two caudal vertebrae, form part of that collection which was sold by Dr. Mantell to the British Museum. No proof is given that these vertebrae belong to the same species as the *Mosasaurus Hoffmanni*: the dorsal vertebrae of the great Mosasaurus of Maestricht are more than double the size of the one above cited, which, in the complete anchylosis of the neural arch, would seem to have belonged to a mature individual of that cold-blooded genus.

Subsequent discoveries of Mosasaurian Fossils in the English cretaceous deposits have enabled the comparison with the specific characters of the *Mosasaurus* of Maestricht, and of that from the Green sand of North America, to be carried out satisfactorily, especially in reference to the modifications of the teeth.

*Mosasaurus gracilis*, Owen. *Lacertians*, Plate 1, figs. 1, 2, and 3. Pl. 2, figs. 1, 2, 3, 4, and 5. Pl. 9, figs. 7, 8, and 9.

Dixon’s ‘Geology and Fossils of the Tertiary and Cretaceous Deposits of Sussex.’ T. XXXIX.

Cuvier,* in his account of the great *Mosasaurus* of Maëstricht, which is entered in the catalogues of M. v. Meyer and M. Pictet, under the synonyms *M. Camperi* and *M. Hoffmanni*, states that “all the teeth are pyramidal, a little curved, with their external surface flat (‘plane’) and divided by two sharp ridges from the internal surface, which is round or rather semi-conical.” Messrs. Von Meyer† and Pictet‡ repeat Cuvier’s description of the external characters of the crowns of the teeth; the one says, “ihre Aussenscote ist eben”—their outer side is flat or level; the other, “leur face externe est plane.” My description§ of the teeth of the Maestricht Mosasaurus, in which it is stated that “their outer side is nearly plane, or slightly convex,” was founded on an examination of the magnificent fossil skull in the Parisian Museum, the original of Cuvier’s description;—and the contour of the base of the crown of a maxillary tooth of the *Mosasaurus Hoffmanni* given in Pl. 10, fig. 7, is taken by accurate admeasurement from a perfect specimen from the Maëstricht chalk: the enamelled crown of this tooth was two inches (five centimeters) in length; the rest of the tooth was formed by the enlarged coarse osseous fang; the total length of the tooth being four inches ten lines (twelve centimeters and a half). Dr. A. Goldfuss, in his highly interesting and instructive description∥ of the skull and teeth of the *Mosasaurus Maximiliani*, accurately describes and figures the finely dentated character of the two opposite longitudinal ridges of the crown; but the feeble indications of angles observable in some of the

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† Palæologica, p. 219.
‡ Traité élémentaire de Paléontologie, ii, p. 63.
§ Odontography, 4to, p. 258.
teeth, those of the upper jaw chiefly, of the Mosasaurus Hoffmanni, do not bear out the term "polygonal" which he applies to the crowns of the teeth of that species, as well as to those of his Mosasaurus Maximiliani; still less can I find these angles so constant and regular as to divide the outer surface of the crown into five, and the inner surface into seven facets; nor have I seen in any maxillary or mandibular tooth of Mosasaurus Hoffmanni that near equality of extent and convexity between the inner and outer surfaces of the crown, which Dr. A. Goldfuss describes (p. 178) and figures in Tab. IX, fig. 4, of the memoir above cited. If that figure accurately represents a maxillary tooth of the same species of Mosasaurus as the one described by Cuvier and recorded by V. Meyer and Pictet under the name of M. Camperi and Hoffmanni; and if the outer surface of the crown is ever flat or level, the range of variety between the two extremes of flatness and convexity is greater than I have yet found in any of the equally well-marked forms of teeth in other fossil reptiles.

The teeth in the specimens of upper and lower jaw of the species of Mosasaur from the chalk-pit at Offham, Sussex, now in the Museum of Henry Catt, Esq., of Brighton, and figured of the natural size in Pl. 2, fig. 1 and 1a, equally differ from the typical form of tooth of the Mosasaurus Hoffmanni, and from those of the Mosasaurus Maximiliani, Pl. 10, fig. 8: the outer surface of the crowns of the mandibular teeth of Mosasaurus gracilis are more convex than those of Mos. Hoffmanni, and are less convex than those of Mos. Maximiliani: not any of the teeth of Mosasaurus gracilis present that angular disposition of the enamel which gives the polygonal form to the pyramidal crowns of the teeth of the Mos. Maximiliani. The lower jaw, Pl. 2, fig. 1, is more slender, less deep in proportion to its length, than in the great Maestricht Mosasaur, and the hinder teeth are relatively smaller and closer together; I have proposed, therefore, to indicate the species by the name of Mosasaurus gracilis. The general form of the crown of the teeth in Mos. gracilis is shown at a, b, and c, fig. 1; an exact contour of the crown a little above its base is given at Pl. 10, fig. 9. The smooth and polished enamel; the inequality of the outer and inner sides of the crown, such as it is; the implanted fang of the tooth thickly coated by a coarse osseous cement; the general ankylosis of the fang to the bony walls of the socket, which rise in a pyramidal form from alveolar border of the jaw; all manifest the peculiar generic characters of the great acrodont marine lizard, Mosasaurus. The maturity of the individual from which the present specimen (Pl. 2, fig. 1) has been derived, cannot be inferred from the solidification and complete development of the ankylosed fangs of the teeth in a class of animals in which those organs are repeatedly shed and renewed: the worn-out teeth, in course of displacement, of the young crocodile, with their alveoli, present in miniature all the senile characters of the corresponding teeth of the mature and aged animal. If, however, the specimen of Mosasaur in question should be adult, it would derive a well-marked specific character from its diminutive size as compared with the Mosasaurus Hoffmanni or Mos. Maximiliani; being only one third the size of the latter,
and one fourth that of the former species. But the characters of immaturity are not manifested by the cold-blooded animals in their osseous and dental systems as they are in the warm-blooded and higher organised mammalia.*

In all the teeth of the *Mosasaurus gracilis* in which the crown is broken, the remains of the pulp-cavity are exposed in the centre of its base: but the immaturity of the specimen is not demonstrated by this character; for, in the largest sized teeth of the *Mosasaurus Hoffmanni*, even in one with a completely developed fang, measuring with the crown nearly five inches in length, I have found a pulp-cavity extending from the base of the crown into the expanded fang, but becoming almost obliterated at the base of the fang. The cast of the crown of a still larger tooth of a *Mosasaurus* from the green-sand of New Jersey, U.S., also shows the remains of a pulp-cavity at its base. This cavity becomes filled in the fossil specimens with the matrix, which is usually chalk; but sometimes the cavity, like the air-chambers of polythalamous shells, is filled with silex.

The number of teeth in each ramus of the lower jaw of *Mosasaurus gracilis* seems not to have exceed twelve. In *Mosasaurus Maximiliani* they are reckoned at eleven;† in *Mosasaurus Hoffmanni* at fourteen; and in this species they are placed closer together than in the *Mos. gracilis*, as may be seen by comparing figure 1 of Pl. 2 with that of the lower jaw given by Camper in the ‘Philosophical Transactions’ for 1786, tab. xvi, which is copied by Faujas St. Fond, in pl. vi, of his ‘Histoire de la Montagne de St. Pierre.’‡ The posterior teeth are rather smaller than the others in *Mosasaurus gracilis*. At the fore part of the jaw the implanted and anchylosed base of the teeth extends through about half the vertical diameter of the jaw; at the posterior part of the series the fangs sink into one third or one fourth the depth of the jaw. The canal, which, as in the crocodile, extends below and along the inner side of the bases of the sockets and anchylosed fangs, is shown, filled by chalk, at d, fig. 1. Traces of the vascular foramina along the outer side of the jaw are visible in the right dentary piece, the outer side of which is exposed: the “splenial” (“opercular,” Cuvier,) element is shown at a, fig. 1, on the left ramus.

In the portion of the left superior maxillary bone (Pl. 2, fig. 1 a) all the teeth are, unluckily, too much broken or abraded to give an idea of the precise form of their crowns; they are rather more compressed at their base than in *Mosasaurus Hoffmanni*: the posterior ridge is much less developed, and the whole of the posterior longitudinally concave border is more transversely convex than in *Mosasaurus Hoffmanni* or *Mos. Maximiliani*. There is as little indication of the angular or polygonal

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* Dr. Goldfuss infers the maturity of his *Mosasaurus Maximiliani* from the characters, of which the inadequacy is explained above. “Die vollständige Verknöcherung aller Theile, so wie die häufigen bemerkbare Aussufflung der Zähne beweisen, dass das Individuum seine vollständige Ausbildung und mit dieser nur die halbe länge des *Mosasaurus Hoffmanni* erreicht hatte.” (Loc. cit., p. 177.)

† Goldfuss, loc. cit. p. 178.

‡ Cuvier, loc. cit. p. 320.
structure in these teeth as in those of the lower jaw; but the enamel shows some longitudinal striations.

All the vertebrae of the *Mosasaurus*, according to Cuvier, are concave at the fore part, convex at the hind part of their bodies; the convexity and concavity being greatest on the anterior vertebrae. The foremost of these are characterised by an inferior process or "hypapophysis," developed from the middle of the lower surface of the centrum: they have two transverse and four articular processes, and a long compressed upper or neural spine. The centrum is longer than it is broad, and broader than it is high; the terminal articular surfaces are transversely oval or reniform. Such are the characters of the last cervical or first dorsal vertebrae. The middle dorsal vertebrae are like these, but have no hypapophysis. Then follow vertebrae which have no articular or oblique processes (zygapophyses), but have longer and flatter transverse processes (diapophyses), and terminal articular surfaces of a pentagonal form, or of a triangular form with the base downwards (see Pl. I. fig. 5). Next come vertebrae with diapophyses and a pair of inferior processes (hypapophyses) for the articulation of chevron-bones (hæmapophyses); afterwards vertebrae without transverse processes and with large anchylosed chevron-bones (hæmapophyses); and finally vertebrae devoid of all processes whatever.

The vertebrae discovered in the Kentish Chalk, with the jaws and teeth above described, and of corresponding proportions to those parts which we observe in the vertebrae of the *Mosasaurus Hoffmannii*, present all the generic vertebral characters of that Lacertian genus, and correspond with the third and sixth kind, or with the posterior dorsal and the anterior caudal vertebrae, as defined by Cuvier. But the terminal articulations of the centrum of the dorsal vertebrae of *Mosasaurus gracilis* present a full oval (not elliptical) form, the long axis of which is vertical and the great end downwards (Pl. 2. fig. 4). The length of the centrum (d, fig. 3), which is three centimeters and a half, or one inch and five lines, exceeds the breadth; but this is equalled by the height of the centrum. The diapophyses in fig. 2, d, are broken away; in fig. 3 it is uncertain whether the surface be a fractured one, or whether it is a natural cavity for the rib; the analogy of *Mosasaurus Hoffmannii* favours the former view of it. The neural arch (fig. 3, n) is anchylosed to the centrum, as in the larger species of *Mosasaurus*. I can perceive only a feeble indication of zygapophyses, which shows that the vertebra (figs. 2 and 3) comes from the posterior region of the back. The neural canal (fig. 4, n) is small and triangular; a sharp longitudinal ridge rises from the middle of its floor, and on each side of this there is a vascular canal descending vertically into the substance of the centrum; this substance presents a coarse fibro-cancellous texture; the areolæ extended longitudinally, and decreasing much in size at the ends of the centrum. The outer surface of the vertebra is smooth; the margins of the anterior articular concavity are sharp.

The vertebra (fig. 2) shows, by the lower position of the diapophysis (d), that it
comes from a more posterior position of the spine than that represented in fig. 3. Figs. 5 and 5a give views (upside down) of a caudal vertebra, which demonstrates another Mosasaurian character in the ankylosis of the haemapophyses or chevron-bones to the centrum, as in the posterior caudal vertebrae of Mosasaurus Hoffmanni; but the hæmal canal (fig. 5a, b) is relatively wider, and the entire centrum is much longer than in the corresponding kind of vertebra figured by Cuvier* or by Faujas St. Fond.†

Three views of the body of a vertebra of the Mosasaurus gracilis, discovered by the Rev. H. Hooper, M.A., distinguished by his geological researches in the neighbourhood of Lewes and Brighton, are given in Pl. 9, figs. 7, 8, and 9. This specimen is from the Sotheram Chalk-pit, near Lewes.

From the genus Leiodon‡ (Pl. 10, fig. 5, 5**) the Mosasaurus gracilis (Ib. fig. 9) differs, like the Mosasaurus Hoffmanni (Ib. fig. 7), in the inequality of the two sides of the crown of the teeth, which are bounded or divided by the anterior and posterior ridges. The Mosasaurus Maximiliani (Ib. fig. 8) differs from the genus Leiodon in the polygonal character of the crowns of the teeth.

The interest which must be excited in the Naturalist and Palæontologist by an extinct Saurian, essentially organised according to the Lacertian type, but developed on a scale surpassing that of the largest existing Crocodiles, and especially modified, as it seems, for aquatic life, leads me to believe, that any additional facts tending to complete its restoration will here be acceptable, although they may not have been afforded by fossils from British strata. In the formations of the Cretaceous Period in North America, answering in mineralogical characters to our Green-sands, though probably contemporaneous with the newest chalk deposits of Europe, many fine examples of Mosasaurus, of the species called by Goldfuss, Mos. Maximiliani, have been found, and the discovery affords a highly instructive instance of the coexistence of particular forms of fossil Reptilia in remote parts of the earth, at the same geological epoch. In a series of remains of the Mosasaurus Maximiliani, from a Green-sand formation at New Jersey, United States, kindly submitted to my examination by Professor Henry Rogers, of Pennsylvania, I detected the basioccipital bone of the cranium, which gave additional evidence of the Lacertian affinities of the Mosasaurus, and new proof of the Cuvierian law of correlation of organic structures. This basioccipital bone, which is figured in the 'Quarterly Journal of the Geological Society,' November, 1849, pl. x, fig. 5, was three inches and a half in length, and four inches nine lines in extreme breadth. It resembled the centrum of the "vertebra dentata" of the Crocodilia, in being convex behind and flattened in front. The convexity formed the inferior and major part of the occipital condyle, which must have been reniform, the angles being superior, and formed by the

* Cuvier, loc. cit., pl. xix, fig. 6, A, B.
† Loc. cit., pl. viii.
‡ Odontography, 4to, p. 261, pl. 72, figs. 1 and 2.
exoccipitals. The rough sutural surfaces for the articulation of these elements were divided by a deep and narrow channel, which gradually expanded towards the condyle. The anterior flat vertical articular surface of the basioccipital was smooth, indicative of a persistent harmonia between it and the basisphenoid, analogous to that which exists between the centrum of the axis and the odontoid process. Two very thick and short exogenous processes (hypapophyses) diverge from the under part of the anterior half of the basioccipital, and terminate in oblique and slightly convex surfaces, irregularly pitted; they resemble the hypapophyses sent off from the basisphenoid in the great Monitor (Varanus), against which the pterygoids abut. This form and structure of the basioccipital of the Mosasaurus harmonizes with the other indications of its Lacertian affinities. The basi-occipital in the Crocodilia sends down a single hypapophys.

No part of the organisation of the Mosasaurus is so little known as that of the locomotive extremities. Cuvier gives copies of drawings which had been transmitted to him of a portion of the scapula,* clavicle,† and coracoid,‡ of a portion of a long bone, which he likens to the cubitus of a Monitor,§ and of an os pubis,|| all of which he believes to have belonged to the Mosasaurus.

The portion of the ulna would indicate, Cuvier remarks, that the Mosasaurus had moderately elevated extremities;¶ but he adds that "the bones of the fore and hind feet, so far as they are known, would seem, on the contrary, to have belonged to a kind of contracted fin, like that in the dolphin or Plesiosaur."

He, however, figures two bones comparable with the two principal bones of the carpus of the Crocodile,†† and which one would scarcely expect to be associated with metacarpals and phalanges like those of the Enaliosaurs. And if the ungual phalanx, figured in pl. xx, fig. 21, of the 'Ossemen's Fossiles,' be rightly attributed to the Mosasaurus, it determines the question in the negative, as to whether that Lacertian reptile had plesiosaurian paddles; the phalanx in question much resembles that in the British Museum (No. 384, Mantellian Catalogue), which has been described as "The Horn of the Iguanodon." The phalanx represented in Pl. xx, fig. 5, of the same work, with almost flat articular ends, must have belonged to a natatory form of foot; but as large Chelonians were associated with the Mosasaurus in the Maestricht beds, it would be rash to conclude that this phalanx absolutely belonged to the Mosasaurus. Cuvier, in fact, sums up by admitting the hesitation which he feels in offering his conjectures as to the nature of the extremities of the Mosasaurus, which were founded on the inspection of drawings.

* Ossemen's Fossiles, tom. v, pt. 2, 4to, pl. xix, fig. 9. † Ib., fig. 14. ‡ Ib., fig. 15. § Ib., pl. xx, fig. 24. ¶ Ib., pl. xix, fig. 10. || "Il annoncerait que ses extremities étaient assez elevées." (Ib., p. 386.) †† "Les os des mains et des pieds, autant qu'on les connaît, semblaient au contraire avoir appartenu à des especes de nageoires assez contractées, et plus ou moins semblables à celles des dauphins ou des plésiosaurs." (Ib. p. 386.)
only, for he says the immediate comparison of the bones themselves would hardly suffice, so great is the diversity and so small the precision of the forms of those bones in reptiles.*

M. Pictet, in the second volume of his 'Traité Elémentaire de Paléontologie,' 8vo., 1845, terminates his brief summary of the characters of the *Mosasaurus*, by stating:—

"Les membres paraissent avoir été terminés par des nageoires aplatis," (p. 62.)

In the collection of Saurian fossils submitted to me by Professor Henry Rogers were some bones of the extremities, showing the Lacertian type of structure, and agreeing in colour, petrified condition, and proportional size with the vertebrae and teeth of the *Mosasaurus* from the same Green-sand formation. They were too large to be attributed to the Crocodilian species indicated by the vertebrae from the same formation. I subjoin, therefore, a brief description of these interesting fossils which appear to me to throw additional light on the structure of the locomotive organs of the *Mosasaurus*.

The first of these bones gave the following dimensions:—

<table>
<thead>
<tr>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme length</td>
<td>2 8</td>
</tr>
<tr>
<td>Extreme breadth of the broader end</td>
<td>0 8</td>
</tr>
<tr>
<td>Breadth of narrower end of the same bone (imperfect)</td>
<td>0 4(\frac{1}{2})</td>
</tr>
</tbody>
</table>

The best preserved extremity of this long bone is expanded and subcompressed, like the lower end of the fibula of the *Varanus*, one part of this extremity being produced into an obtuse angle. The extremity is smooth, slightly concave transversely on one side, more irregular on the opposite side, with a thick prominent border opposite to the produced angle. The shaft of the bone has an irregular full, oval, transverse section with dense walls of concentric plates of bone, eight or nine lines thick, surrounding a medullary cavity, one inch nine lines in diameter. The shaft is very slightly bent. The opposite extremity which gradually expands, preserving the general form of the shaft, exhibits a strong longitudinal ridge of six inches in extent, but which subsides before it reaches the articular end. Only a portion of this end is preserved, which is slightly and irregularly convex.

The second long bone of the extremity yields the following dimensions:—

<table>
<thead>
<tr>
<th>Feet</th>
<th>Inches</th>
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</thead>
<tbody>
<tr>
<td>Extreme length</td>
<td>2 5</td>
</tr>
<tr>
<td>Breadth round the upper (?) articulating surface</td>
<td>0 4(\frac{1}{2})</td>
</tr>
<tr>
<td>Depth of articulating surface</td>
<td>0 3(\frac{1}{2})</td>
</tr>
<tr>
<td>Breadth of lower (?) end (imperfect)</td>
<td>0 3</td>
</tr>
</tbody>
</table>

This bone, therefore, equals in length the preceding, but becomes more attenuate in the middle than any of the long bones in the existing *Saurians*; one extremity is

* Loc. cit., p. 357.
compressed, and terminates in a slightly convex, thick, smooth articular border. Nine or ten inches below this, the shaft, slightly increasing in breadth and decreasing in thickness, presents a thick, rough, and prominent ridge, three inches and a half in length, apparently for the attachment of some strong muscle; behind this ridge the shaft contracts to a diameter of one inch nine lines, and to a circumference of four inches six lines. At ten inches from the distal end it increases in thickness, assumes a trihedral form, with one edge produced and convex, subsiding above the articular end, which is in the form of a simple convex condyle, not excavated for a troclear joint in the middle, but with an irregular branched impression or smooth groove at that part: the articular surface extends upon the fore and the back part of the shaft, about two inches six lines from the end, contracting posteriorly, and with a convex border anteriorly above, where there is a shallow semilunar depression. There is a very deep large hemispheric pit on each side above this condyle. There is no medullary cavity in this bone.

These two long bones are more like the tibia and fibula of the larger lizards than the radius and ulna: there can be little doubt that they belong either to the leg or to the antibrachium, but they differ too much in shape from any of the bones of those segments in the larger lizards, with which I have been able to compare them, to encourage me to hazard a positive determination. I should be disposed to ascribe them, from their length and slenderness, to the hind leg. They are more Lacertian than Crocodilian in their general character; and they belong with great probability to the Mosasaurus.

A metacarpal or metatarsal bone of the same reptile gives the following dimensions:

<table>
<thead>
<tr>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme length</td>
<td>1 8</td>
</tr>
<tr>
<td>Extreme breadth of the broader articulating surface or upper end</td>
<td>0 4(\frac{1}{2})</td>
</tr>
<tr>
<td>Central depth of ditto</td>
<td>0 3(\frac{1}{2})</td>
</tr>
<tr>
<td>Breadth of lower end</td>
<td>0 3</td>
</tr>
</tbody>
</table>

The proximal or upper end is suddenly expanded, with an undulated or partly convex partly concave articular surface, nearly flat, at right angles to the shaft; sub-triangular with the angles rounded off, or reniform on account of the deep notch posteriorly, below which there is a depression. A ridge is continued from the shaft upon two of the angles, which gives a subhemispheric section of the shaft at six inches from the head. Here a medullary cavity nine lines in diameter is exposed. One half of the parietes of the middle third of the shaft of this bone is preserved, which shows a continuation of the medullary cavity and the development of an angular ridge from the shaft, which subsides about six inches from the distal end. This end slightly expands into a simple convex condyle, with the articular surface
irregularly grooved, and with a large deep hemispheric pit on one side above the surface, but not on the other.

The above-described long bones were taken back by Professor Rogers to America; the following specimen he liberally permitted me to retain.

A metacarpal or metatarsal bone rather larger than the preceding, with the notch at the proximal end much less deep. The angular border or ridge, continued from one of the posterior rounded angles of the articular surface, quickly subsides; that from the other angle is continued down from the middle of the shaft, giving it an oval transverse section. The fracture of the shaft, nine inches from the head of the bone, exposes an oval medullary cavity, nine lines in the long diameter. The longitudinal ridge is developed from the distal half of the bone, as in the former, and it terminates in a simple convex condyle with the grooved sculpturing upon the articular surface, and with the large deep hemispheric pit for a ligament, on one side of the trochlea, and a large shallow notch on the opposite side.

The following two bones of the toes conform to the Lacertian type, and not to that of the Enaliosauria. The first is a proximal phalanx of a toe of apparently the same Saurian as the bone last described. The proximal articular surface appears to have been subcircular, very slightly concave, with a few shallow pits and grooves in the middle, like those on the end of the metatarsal. The shaft gradually contracts, and becomes more convex in front than behind; it subsides into a shallow depression above the forepart of the distal trochlea, on each side of which there is a large and deep ligamentous pit. Its dimensions are as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme length</td>
<td>5</td>
</tr>
<tr>
<td>Breadth of upper articulating surface</td>
<td>2 1/2</td>
</tr>
<tr>
<td>Depth of ditto</td>
<td>2</td>
</tr>
<tr>
<td>Breadth of lower articulating surface</td>
<td>1 1/4</td>
</tr>
<tr>
<td>Depth of ditto</td>
<td>2</td>
</tr>
</tbody>
</table>

The second specimen is a second phalanx of apparently the same toe; having an expanded, concave, proximal, articulating surface, adapted to the distal surface of the preceding bone; and terminated by an oblique broad convex trochlear articulation. Its dimensions are as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme length</td>
<td>3 1/2</td>
</tr>
<tr>
<td>Breadth of upper articulating surface</td>
<td>2 1/4</td>
</tr>
<tr>
<td>Depth of ditto</td>
<td>2</td>
</tr>
<tr>
<td>Breadth of lower articulating surface</td>
<td>2</td>
</tr>
<tr>
<td>Depth of ditto</td>
<td>1 1/2</td>
</tr>
</tbody>
</table>

On the highly probable supposition that the above-described long bones belong to the Mosasaurus, they indicate the extremities of that gigantic lizard to have been
organised according to the type of the existing Lacertilia and not of the Enaliosauria or Cetacea. But a foot so organised for crawling on land might, nevertheless, by the webbed union of the large and long unguiculate claws, have been well adapted, like the feet of the Amblyrhynchus and Alligator, for swimming; and the modifications of the vertebral column, especially of the long and deep tail of the Mosasaur, clearly prove it to have been more strictly aquatic in its habits than any known existing lizard.*

The vertebra from the Chalk near Lewes (Pl. 1, figs. 1 and 2) above alluded to, which is the subject of the cut, No. 2, p. 146, of Dr. Mantell's 'Geology of the South-East of England,' is one of those posterior dorsal or lumbar vertebrae, in which the diapophysis (d) arises from near the middle of the side of the centrum, and has a depressed flattened form, at its origin, instead of the thicker subcompressed form that characterises the same process in the anterior dorsal vertebrae. The specimen in question is much mutilated; both the neurapophyses, n, the diapophyses, d, and part of the left side of the centrum, are broken away; but the rarity of such evidences of the Mosasaurian genus in our English Chalk, and the historical interest attached to this, which is one of the first specimens discovered, has induced me to give an accurate figure of it in Pl. 1, fig. 4, together with one of the homologous vertebrae of the Maëstricht species (fig. 4), which is preserved in the British Museum. The specimen from Lewes presents the following dimensions:—

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Inches</th>
<th>Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of the centrum</td>
<td>. . . . . .</td>
<td>2 0</td>
</tr>
<tr>
<td>Vertical diameter of ditto</td>
<td>. . . . .</td>
<td>1 4</td>
</tr>
<tr>
<td>Transverse diameter of ditto</td>
<td>. . . . .</td>
<td>1 6</td>
</tr>
<tr>
<td>Length of the base of the neural arch</td>
<td>. . . . .</td>
<td>1 8</td>
</tr>
</tbody>
</table>

The neural arch, n, has completely coalesced with the centrum: it terminates behind, about four lines from the convex articular end of the centrum. The marginal circumference of that surface, fig. 2, has been worn away, but it evidently presented a more obovate and less triangular figure than in the Mosasaurus Hoffmanni, fig. 5. The fractured base of the diapophysis, shown at d, fig. 1, is situated lower than half-way down the side of the centrum.

The two caudal vertebrae (Pl. 1, fig. 3) have been retained in natural juxtaposition in the same block of Chalk. Both the neural (n) and hæmal (h) arches have coalesced with the centrum without any trace of the primitive sutures, the antero-posterior extent of the neurapophysis is relatively shorter than in the more advanced vertebra,

* M. Hermann von Meyer, in his comprehensive and useful summary of Fossil Remains, entitled 'Palæologica,' 8vo, 1832, classifies the Mosasaurus with the Plesiosaurus, in the Order of Sauria, characterised by fins. ("Saurier mit flossartigen Gliedmassen," p. 201.)
CRETACEOUS LIZARDS.

as is shown by fig. 6 as compared with fig. 4, and by the following admeasurements of one of the caudal vertebrae:—

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Inch</th>
<th>Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of the centrum</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Vertical diameter of the convex end</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Transverse diameter of ditto</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Length of the base of the neural arch</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Length of the base of the haemal arch</td>
<td>0</td>
<td>9</td>
</tr>
</tbody>
</table>

The haemapophysis (h) swells outwards at its origin, before it bends downwards, backwards, and inwards to unite with its fellow in order to complete the arch. The area or span of this arch has been considerable, as in the vertebra, fig. 5 a, Pl. 2, and as it is in the Mosasaurus Hoffmanni: it is probable that the spinous process continued from it had a corresponding remarkable length, but of this the fractured condition of the specimen affords no proof. The lateral surface of the centrum is smooth, with many small vascular perforations. There is a slight but well-marked rising above the base of the haemapophysis, at d, fig. 3, Pl. 1, which seems to indicate a last rudiment of the diapophysis. A narrow vertical ridge (r) extends about two lines from the border of the posterior convex surface, as if it were indicative of the limits of an epiphysis which had formed that surface. The border of the anterior concave surface has been worn or broken away. A linear impression gives also an indication of an epiphysis in the dorsal vertebra of the Mosasaurus Hoffmanni. The slight degree of concavity and convexity of the terminal articular surfaces of the centrum in these vertebrae is characteristic of the genus. In their special characters, the small vertebrae from Lewes correspond with the vertebrae attributed to the Mosasaurus gracilis, which are longer and more slender than those of the Mosasaurus Hoffmanni.

Genus.—Leiodon, Owen.

'Odontography,' p. 261, pl. lxxii, figs. 1 and 2.


The teeth from the chalk of Norfolk, surmised by Dr. Mantell, from "their symmetrical, conical form, and other characters," to belong to an unknown reptile, or to a sauroid fish;* and described and figured in my 'Odontography'† as characteristic of a new genus of Mosasauroid Reptiles, under the name of Leiodon,‡ presented

‡ Λειοδών, smooth, oδοίς, tooth.
the same acrodont type of dentition as in *Mosasaurus* and *Geosaurus*, but differed in their closer arrangement and from the former, especially, in the shape of the crown, of which the outer side was as convex as the inner side, the transverse section being an ellipse with pointed ends, which latter corresponded with two opposite trenchant edges dividing the outer from the inner side of the crown. This was covered by a smooth enamel without any indications of minor ridges or facets: the apex of the crown was sharp-pointed; the body of the crown slightly recurved; and its base expanded into a thick fang of a circular form, which was anchylosed to a short conical process of the alveolar border of the jaw.

Deducing the generic dental characters of *Mosasaurus* from the magnificent example of the jaws and pterygoid bones, which passed from Dr. Hoffmann's collection to that of the Canon Goddin, and ultimately to the Museum of the Garden of Plants at Paris, the deviation in the teeth in question from the inequilateral faceted character of the crowns of the maxillary and mandibular teeth of that specimen was so great, as to lead me to infer that these teeth from the English chalk belonged to a distinct genus of the same family of the Lacertine order; unless, indeed, they might be pterygoid teeth of a species of *Mosasaurus*, distinct from the *Mosasaurus Hoffmanni*. After a rigid comparison in reference to this question, I was led to the conclusion that they were not pterygoid, but maxillary teeth, and I therefore described them under the name of *Leiodon aniceps*. The general results of that comparison, which would have been out of place in a systematic Treatise of Teeth in general, will here be requisite.

**Leiodon aniceps, Owen.** Lacertians, Plate 10.

‘Odontography,’ 1840, vol. i, p. 261; vol. ii, pl. 72, figs. 1 & 2.


Baron Cuvier, after a close and accurate description of the pterygoid bones of the great *Mosasaurus Hoffmanni*, concludes by stating, that “each of these bones seemed to have supported eight teeth, which grew, became attached, and were replaced, like the teeth of the jaws, but were much smaller.”* They also differ from the jaw-teeth by having their two sides less unequal in regard to their convexity; the inner side is almost as convex as that side of the maxillary teeth, but the outer side of the

*"Cet os paroit avoir porté dans notre animal fossile huit dents qui croissoient, se fixoient et se remplaçoient comme celles des mâchoires, quoique beaucoup plus petites."* (Ossemens Fossiles, tom. v, pt. ii, p. 324, 4to, 1824.)
pterygoid teeth is more convex than the nearly flat outer side of the maxillary teeth. They resemble, in fact, in their transverse section, the lower maxillary teeth of the *Mosasaurus Dixoni*. The alveolar border to which the pterygoid teeth are attached in the *Mosasaurus Hoffmanni*, is moderately convex towards the cavity of the mouth; the alveolar tract is relatively thicker or broader than on the jaws, and the germs of the new pterygoid teeth appear almost like a second small row on the outer side of that row which is in place, being less close to the teeth they are destined to replace than they are in the maxillary series.

The teeth in question from the English Chalk, differed in the shape of their crowns from the pterygoid teeth of the *Mosasaurus Hoffmanni*, and the alveolar border to which they were attached, more resembled that of the dentary piece of the lower jaw. In the smoothness of the enamelled crown, its compressed elliptical form and trenchant borders, (Pl. 10, figs. 5, 6,) which, when magnified, presented a fine serration, the teeth in question, approached to the characters of those of *Geosaurus*, as much as they deviated from those of *Mosasaurus*. Both *Mosasaurus* and *Geosaurus* afford types of the acrodont mode of dental attachment. Had only the teeth and portions of the jaws of the *Geosaurus* been known they might have been registered, on such limited evidence, as having belonged to a species of *Mosasaurus* distinct from the *Mosasaurus Hoffmanni*, and the Anatomist, Soemmerring, even supposed that the *Geosaurus* might be merely the young of that species. But the differences in the shape of the teeth are associated with differences in the structure of the cranium, of the sclerotic, and, what is still more important, in that of the vertebrae themselves, which are sub-biconcave and contracted in the middle of the centrum. With these evidences, therefore, of the importance of the differences indicated by different forms of the teeth of the acrodont *Sauria*, one may be justified in the expectation that the *Leiodon* will prove to be a genus alike distinct from both *Mosasaurus* and *Geosaurus*, and, as probably tending to fill up the hiatus that divided those genera in the series of Acrodonts, as it was known to Cuvier.

The additional evidence which has been received in elucidation of this highly interesting family of Saurians, since the publication of my 'Odontography,' has tended to confirm the conclusions stated in that work relative to the *Leiodon anceps*. The *Mosasaurus* of the Green-sand Formations in North America, (Pl. 10, fig. 8,) has been satisfactorily shown in Professor Goldfuss's Memoir, to be a species distinct from that of the Cretaceous Deposits at Maestricht, (ib, fig. 7.) The maxillary teeth show the same generic characters, the two sides being unequal, but with specific modifications. The pterygoid teeth are ten in number on each pterygoid bone, attached in like manner to an alveolar border, which is convex both downwards and outwards: all the crowns of these pterygoid teeth had been unfortunately broken off and lost.

Mr. Charlesworth has described and figured in the first part of the 'London Geological Journal,' a portion of jaw-bone, with five teeth, of the *Leiodon anceps*, which
he states to have come into his possession from "one of the numerous chalk-pits on
the Essex side of the Thames"—the side on which the county of Norfolk lies; and it
appears that the teeth described and figured in my 'Odontology' are not only
specifically identical, but once formed part of the same specimen, with that which
he has since figured. This may well be, for in the mass of materials which I had been
collecting for six years previous to the publication of my 'Odontology' I found the
drawings, which are engraved in Pl. 72, figs. 1 and 2 of that work, marked 'from the
chalk of Norfolk,' without any other memorandum, and I feel obliged to Mr. Charles-
worth for having publicly supplied in 1846, what my memory in 1840 failed to do,
viz., the reference to the individual to whom I had been indebted in 1835 for the
loan of the originals of those drawings.

With regard to the question of the nature and affinities of the *Leiodon*, the
additional evidence which the figures published by Mr. Charlesworth afford, is of
value. The teeth in that specimen can only be referred to the genus *Mosasaurus*, as
characterised by Cuvier and Goldfuss, on the supposition that they are 'pterygoid teeth.'
But, in an extent of an alveolar tract of seven inches, and including five teeth, (Pl. 10,
fig. 1,) that tract is slightly concave lengthwise, instead of being convex; and it wants
the horizontal platform extended to the outside of the teeth in place, and supporting
the nidus of their successors, which characterises the pterygoid bones (see fig. 4).

In my 'Odontology,' I have briefly noticed one of the most common conditions
of fossil teeth, in which the pulp-cavity has not been obliterated by calcification of the
pulp itself in the lifetime of the animal. Thus, in the section on the teeth of the
*Ichthyosaurus*, it is described in the following passage. "The remains of the pulp,
after the formation of the due quantity of dentine, became converted, as in the
pleodont lizards, by a process of coarse ossification, into a reticulate, fibrous, or
spongy bone; but it continued open at the crown after the basal part of the tooth was
thus consolidated, as is shown in the longitudinal section, (Pl. 73, fig. 8,) wherein a
is the pulp-cavity, filled with crystallized spath, b the ossified pulp at the base of the
tooth." p. 279. In fig. 2*, Pl. 10, is reproduced Mr. Charlesworth's figure of the
mass of similar siliceous spath, that, in like manner, filled the uncalcified part of the
pulp-cavity of the tooth of the *Leiodon anceps*. Although I should not have called this
"a very unlooked for condition of the interior of the tooth," I concur with the Editor
of the 'London Geological Journal' in his hypothesis of the precipitation of the
siliceous matter from a fluid. But, at the same time, I am fully conscious how trans-
parent a veil such an hypothesis is to our ignorance as to the precise conditions of the
precipitation of such matter in the interior of fossil teeth, in the medullary cavities of
fossil bones, and in the closed chambers of many polythalamous shells. The only
wonder connected with the fact illustrated in Pl. 10, figs. 2 and 2*, is, that any Geologist
should deem it an unlooked for or extraordinary one.

I have described and figured some small detached crowns of the teeth of the *Leiodon,*
from the Chalk-pits of Sussex, in my friend Mr. Dixon's Geology of the Tertiary and Cretaceous Deposits of that County, Tab. XXXVII, figs. 10, 11, and 12. One of the finest and most characteristic teeth of this genus was discovered in the Chalk, during the cutting of the Brighton and Lewes Railway: it is figured in Pl. 10, figs. 6 and 6*, of the present Work, and is now in the fine Collection of Henry Catt, Esq., of Brighton.

CHAPTER III.

Order. CROCODILIA.

Genus.—**Crocodilus**? Crocodilia, Plate 30.

In the Museum of Mr. Saull, F.G.S., there is a small block of green-sand from the County of Sussex, containing several parts of a small, and apparently very young crocodile. The portion of the upper jaw, and of the right ramus of the lower jaw, (Pl. 30, figs. 1 and 2,) demonstrate the crocodilian shape and mode of implantation of the teeth, which have thick, subconical, obtuse crowns, and present proportions most resembling those of the *Goniopholis crassidens*.* The alveolar border of the jaw has a similar wavy outline, and so differs from that in the Gavials and Teleosaurs, in which the alveolar border is straight. The sockets of the teeth, which are distinct at the anterior half of the jaws, run together at the posterior half, as in the Alligators and the young Crocodiles of the existing species. Several bony scutes are preserved, as, e.g., at °° fig. 3; none of which show the tooth-like process at one angle, which characterises many of the scutes in the *Goniopholis*: and as there is not a single centrum, or body of a vertebra to give the characters of the articular ends of that part, I am unable at present to determine the species. The femur, 65, is longer and more slender in proportion to the ischium, 63, than in the Nilotic or Indian Crocodiles: and the tibia, 66, and fibula, 67, are longer in proportion to the femur. This species evidently had the hind legs proportionably more developed than in existing *Crocodilia*, and better adapted for swimming,—a character which is observable in the Teleosaurs and some other Crocodiles of the secondary formations. At the same time it should be remembered that, in the Green-sand Formations of New Jersey, vertebrae of two species of Crocodiles or Alligators have been discovered by Professor Henry Rogers, constructed on the same procoelian type as those of existing species. See 'Quarterly Journal of the Geological Society,' January, 1849, p. 380, pl. x.